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CHEMISTRY

FOR BEGINNERS.

BY

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SECOND EDITION.

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CHEMISTRY FOR BEGINNERS.

PART FIRST.

CHAPTER I.—WORDS AND PHRASES.

1. WHATEVER relates to the composition of any physical body, belongs to chemistry. For example, the rust which collects on Iron exposed to air and moisture is composed of Iron and a gas called Oxygen. Soda water and champagne wine owe their sparkling appearance to the presence of Carbonic Acid gas. It is chemistry which makes us acquainted with these facts.

2. Chemistry embraces all matter. That is to say, every material object in the world, as water, air, minerals, vegetables, animals, is included in its province; and many of the phenomena they present are explained by its principles. Chemistry teaches us how the elements of matter combine together, and separate from one another; and, although not strictly within its scope, it also makes us acquainted with their physical properties, as color, taste, smell. Whatever is perceptible to our senses is matter.

3. To simplify description, the particles of every kind of matter may be classed under two heads, namely, integrant and constituent particles. The word integrant refers to particles of matter in a state of mechanical division; the phrase constituent particles refers to the ingredients of which the substance is composed. Thus, if we take a piece of marble and pound it in a mortar, the fragments would be integrant particles of the marble; but if upon one of these fragments we poured Hydrochloric Acid, it would be decomposed into its constituent particles,—Carbonic Acid and Lime.

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4. COHESION is the force which keeps the integrant particles of bodies together. In some substances it is more powerful than in others. It is the varying amount of this force which makes some bodies hard, others soft, some tough, others brittle. Cohesion is exerted between the particles of liquids as well as of solids, though not so powerfully in the former as in the latter case. Cohesion is also exerted between liquids and solids. If we fill a glass with water, and then pour out all that we can by inverting it, a portion of the water will still cohere to the inside of the glass.

5. The union of the constituent particles of bodies is called CHEMICAL COMBINATION. There are three important laws which regulate this force.

I. Chemical combination takes place between the elements of matter, and occurs at insensible distances. In other words, it is not the one mass adhering to the other, as in two pieces of wet clay; nor a mechanical mixture, as in agitating sand and water together; but a real union of the elements of the one with those of the other, as when fat combines with potash ley to form soap.

II. Chemical combination is characterized by a change of properties, a third substance being formed, which differs from both of its constituents. Thus, Sulphuric Acid added to Magnesia forms Epsom salts. These changes are almost infinitely varied. Liquids are changed into solids; as when a saturated solution of Chloride of Calcium is added to one of Carbonate of Potash. Sometimes solids are converted into liquids during the act of union; as when freshly crystallized Sulphate of Soda and Nitrate of Ammonia are rubbed together in a mortar. Frequently two colorless liquids produce a brilliant colored solid; as when a solution of Iodide of Potassium is cautiously added to one of Bichloride of Mercury, both of which are colorless, we have a red powder thrown down. Change of temperature is a common occurrence; as increase of heat, when Sulphuric Acid is added to Water, in certain proportions; or reduction of heat, when Hydrochloric Acid is poured on Sulphate of Soda. Chemical combination, however, is very much influenced by circumstances. As a general rule, whatever increases the contact of the particles facilitates combination. Thus, the state of me-

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chanical division in which the substances are brought together considerably influences their union. A lump of Antimony put into a jar of Chlorine combines very feebly with the gas, if at all; but if we reduce the same lump to powder, and throw it into a jar full of Chlorine, rapid combination will ensue, attended with heat and sparks of light. Solution, acting on the same principle, favors combination. Dry Tartaric Acid and dry Carbonate of Soda, brought into the closest possible contact, remain unchanged; but, when we add water, the Carbonate of Soda is immediately decomposed, with effervescence. Friction, in some cases, causes combination. Take a dry mortar, and pound two grains of Sulphur along with as much Chlorate of Potash, rubbing them smartly together. Combination results, attended by explosions. Light and heat also influence chemical combination.

III. All bodies, in chemically combining, do so in fixed and definite proportions. Thus, one part by weight of Hydrogen always unites with eight parts of Oxygen to form Water. There is a certain fixed proportion in which each individual element combines with any other, called its combining proportion, or, equivalent number. Hydrogen is employed as the basis of the scale, and reckoned 1. (See par. 37.) Some bodies combine in more than one proportion, that is, they combine with two, three, four, or more proportions, each time forming a new substance. The compounds formed by the union of Oxygen with Nitrogen are examples of the law. (See par. 88.) There is a beautiful simplicity in this arrangement; for experimental research has determined that when one body is capable of uniting with another in several proportions, these are invariably simple multiples of each other. We may have two, three, or more proportions of one element in a chemical compound, but never a fractional part.

6. ANALYSIS means, taking to pieces. By it, chemists find out the nature and quantity of the ingredients present in any compound. It is divided into qualitative and quantitative analysis, phrases sufficiently expressive.

7. DECOMPOSITION also signifies, taking to pieces. It often occurs spontaneously, and is a result in many processes not undertaken for analysis.

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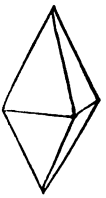
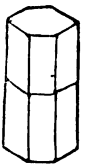
8. SYNTHESIS is the name of the process whereby we prove the composition of a body by reuniting its elements together. Thus, when an electric spark is passed through a vessel containing Oxygen and Hydrogen gases, Water is formed by the combination of the two. This is called synthetical proof; the preceding is called analytical proof; and when both concur as to the composition of any substance, the evidence is in the highest degree satisfactory.

9. Solid matter presents itself in two forms, namely, amorphous or shapeless masses, and CRYSTALS. Two things are necessary to constitute a crystal; it must have a regular shape, and this shape must be the result of a natural process. The accompanying figures represent the forms of two crystals. It would be easy to cut a piece of wood to either of these shapes, but such would not be a crystal. It is essential to the existence of a crystal that it be formed by natural, not by artificial means.





10. There are three principal ways in which crystals may be produced; namely, solution, fusion, and sublimation.

11. SOLUTION is the most frequent method. The agent employed may be water, spirit, ether, turpentine, &c., and is called a solvent. The solution is called hot or cold, according to the temperature of the solvent. When the liquid has dissolved as much as possible of the solid, it is called a saturated solution. As the liquid portion evaporates, the substance dissolved is deposited in a crystalline form. The resulting mass is called a crop of crystals, and the remaining liquid is the supernatant or mother liquor. Those liquids which dissolve a solid without changing its properties are called simple solvents. The solution of sugar in water is an instance. But those which form a new body during solution are called chemical solvents. Calcined Magnesia is not soluble in water; but Sulphuric Acid readily dissolves it, and the resulting solution is a new body, — Sulphate of Magnesia, or Epsom salts.

12. FUSION consists in the liquefaction of a solid body by heat. To procure crystals of Lead, Bismuth, or Sulphur,

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by this method, the fused matter must be allowed to cool slowly. Take a Hessian crucible, three-fourths full of the substance to be crystallized, and place it in the centre of a good fire, until the material liquefies. Then take it out, and, having allowed it to cool until a crust forms on its surface, break through this, and pour out the remaining liquid. After a gradual, complete cooling, the crucible itself may be broken, and crystals will be found on its inner surface.

13. SUBLIMATION means the conversion of a solid body into vapor, and the after condensation of that vapor into a solid, which often possesses a crystalline form. The substance thus operated upon is called a sublimate. This process is employed to purify Sulphur.

14. Most crystals contain a certain amount of water, called the water of crystallization. This water is not held by a very strong force; a little heat being generally sufficient to drive it off, in which case the substance loses its crystalline form. Some crystals naturally absorb moisture from the atmosphere, and are said to be deliquescent, such as those of Chloride of Calcium. Others, under the same circumstances, give up a portion of water to the atmosphere, crumbling down; and these are called efflorescent. Carbonate of Soda crystals act in this way.

15. PRECIPITATION means the throwing down of a solid substance from a liquid, by a chemical agent. It involves the decomposition of one or both of the materials used. Add a solution of Chloride of Barium to a glass of water containing a few drops of Sulphuric Acid. A solid powder, in a minute state of division, falls to the bottom of the glass. This is Sulphate of Baryta; and it becomes precipitated on account of being insoluble in water. The substance thrown down is called a precipitate, and the agent employed is called a precipitant.

16. FILTRATION is the process whereby a precipitate, or any other solid matter, is separated from a liquid. It is sometimes employed to get rid of the solid matter, and thus purify the liquid, as in filtration of lake or river water to supply cities; and often by the analytical chemist for the sake of the precipitate, which is collected on a filter. Filters are made of unsized paper (white blotting paper answers very well), the pores of which are

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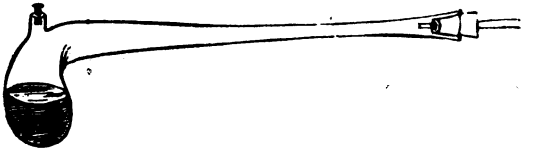
large enough to allow liquid to pass through, though too small for solid particles. In preparing crystals by solution, the liquid requires to be filtered; and in this case it is the portion which passes through that is preserved and operated upon.

17. Evaporation. — Liquids evaporate at all temperatures. When no artificial heat is applied, the process is called spontaneous evaporation, and by this method the largest crystals are procured. This is a slow process, however; and it is more common to apply gentle heat by means of a spirit-lamp, or a sand-bath.

18. Distillation is the name of the process whereby a volatile liquid is separated from one not so easily vaporized. Heat is applied to the mixture; a portion rises in vapor, and this is again reduced to the liquid form by applying cold. Distillation is effected on the large scale in copper stills; but glass vessels like the woodcut, called retorts, are commonly used by experimental chemists.



19. An acid, in general terms, is a substance which tastes sour, and reddens litmus paper or an infusion of dark-blue cabbage. Sulphuric Acid is an example.

20. An alkali is a substance which renders turmeric paper brown, has an acrid, burning taste, and in solution has a peculiar slippery sensation to the touch. The principal alkalies are Potash, Soda, and Ammonia. They may be combined with fats or oils, and then soap is formed. In their uncombined state, alkalies have great cleansing power. Lime also turns turmeric paper brown, and by some is regarded as an alkali.

21. A base is any body capable of combining with an acid to form a new and definite compound. Potash is a base; it may be made to combine with Sulphuric Acid, when Sulphate of Potash results.

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22. SALT was the name formerly restricted to compounds formed by the union of an acid with a base, but is now applied to many bodies which contain no acid. Sulphate of Potash is a salt; and Chloride of Sodium, or common salt, is an example of the kind that contains no acid.

23. An ELEMENT is a simple body, as distinguished from a compound body. All bodies which chemists have hitherto been unable to reduce to a simpler form, are set down as elements. Sulphur is an element, so far as is at present known, because by no process have we succeeded in decomposing it into simpler parts.

24. SPECIFIC GRAVITY signifies the comparative weight which different bodies bear to each other. In order to simplify calculations, Water is taken as the standard of comparison for liquids and solids, and reckoned 1 or 1.000. Thus, the specific gravity of Lead is 11; or, in other words, Lead is eleven times heavier than Water — the standard.

25. A pair of small scales, such as those used by apothecaries, with a set of grain weights, are required. See that the scale-pans are equally poised before weighing.

26. To ascertain the specific gravity of a liquid, take a light glass flask, clean and dry, and make a metallic counterpoise for it. Fill it with distilled water, and weigh, placing the counterpoise in the opposite scale-pan. Empty the flask, dry it thoroughly, and fill to the same height with the liquid of which you wish to find the specific gravity. Again weigh, adding the counterpoise as before. Then say, as the weight of the water is to the weight of the liquid, so is 1.000 to the specific gravity required. When the flask contains 300 grains of distilled water (at which spot a mark should be made on the neck with a file), the process may be still further simplified, by dividing the weight of the liquid under examination by 3, which will give the specific gravity.

EXAMPLE. — SULPHURIC ACID.

Distilled Water in flask . . . . 300 grains.
Sulphuric Acid in flask . . . . 555 ,,

Then as 300 : 555 : : 1.000 = 1.850, sp. gr. required.

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EXAMPLE. — DILUTE ALCOHOL.

Distilled Water	300 grains.
Dilute Alcohol	250 ,,

Then as 300 : 250 : : 1.000 = 0.833, sp. gr. required.

27. To find the specific gravity of a solid which is heavier than water, and insoluble in it, attach a piece of the solid, by a fine silk thread, to one scale-pan, and ascertain its weight as thus suspended. Then immerse the solid wholly in distilled water, and again weigh. A loss of weight will be observed; which loss exactly corresponds to the weight of a portion of water the same size as the solid introduced. Then say, as this loss is to the weight of the solid in air, so is 1.000 to the specific gravity required.

EXAMPLE. — LEAD.

Lead weighed in air	66 grains.
Do. weighed in water	60 ,,
Loss	6 ,,

Then as 6 : 66 : : 1.000 = 11, sp. gravity of Lead.

28. If the solid is lighter than water, the following plan may be adopted. Select a piece of metal sufficiently heavy to sink the light body in water. Weigh the light body and the metal separately in air, and the metal also in water; tie them together with thread, and weigh them in water as thus attached. Add together the weight of

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the light body and the metal in air. Subtract from this their joint weight in water. From what remains, subtract the difference betwixt the weight of the metal in air and its weight in water. The remainder will show the weight of a portion of water equal in bulk to the light body; and as the weight of this portion of water is to the weight of the light body in air, so is 1.000 to the specific gravity required.

EXAMPLE. — CORK.

Cork weighed in air	10	grains.
Type-metal weighed in air . . .	225	,,
Ditto in water	202	,,
Joint weight in water	154	,,
From joint weight in air	235	,,
Subtract joint weight in water . .	154	,,
Leaves	81	,,
Sub. dif. bet. wt. of m. in air and water	23	,,
Remainder	58	,,

Then as 58 : 10 : : 1.000 = 0.172, sp. gravity of Cork.

29. To ascertain the specific gravity of a solid which is soluble in water, prepare a saturated solution of the substance, by adding it in powder to boiling water so long as it is dissolved. Allow the solution to cool; then filter, and take the specific gravity of the filtered liquid. Then put 100 grains of the substance in powder into the flask, fill up with the saturated solution, and weigh, using the counterpoise for the weight of the flask itself, as before. This is the whole process, as far as manipulation is concerned. The calculation is as follows. Add 100 (the weight of the solid introduced) to the original weight of the saturated solution. Subtract from this total the weight of the saturated solution with the 100 grains in it. The remainder will show the weight of a portion of water equal in bulk to 100 grains of the solid. Then, as this remainder is to 100, so is the specific gravity of the saturated solution to that of the solid required.

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EXAMPLE. — NITRATE OF LEAD.

Distilled water	300 grains.
Nitrate of Lead solution . . .	427 ,,

Then as 300 : 427 : : 1.000 = 1.423, sp. gr. of solution.

Add 100 to 427	527 grains.
Solution with 100 grs. weighed .	495 ,,
Leaves	32 ,,

Then as 32 : 100 : : 1423 = 4.446, sp. gr. Nit. Lead.

30. The specific gravity of gases is found out by comparing them with atmospheric air, which is reckoned 1 or 1.000. Thus, the specific gravity of Chlorine gas is 2.47, or, bulk for bulk, about two and a half times heavier than atmospheric air. But as the processes are difficult to perform, and the necessary apparatus expensive, we will not enter upon them here.

31. There are many more phrases occasionally used by chemists, some of which will be introduced as we proceed. Further explanations will also be given of some of those already mentioned.

CHAPTER II. — NON-METALLIC ELEMENTS.

32. The ancients regarded earth, air, fire, and water as the only elements; but modern chemists have proved that none of these are entitled to the name. Air and water are definite compounds. Earth is a generic name for many different compounds; and fire is merely a phenomenon attendant upon certain chemical changes.

33. There are sixty-two elements in nature; but a great number of these are of rare occurrence, imperfectly known, and of little interest to any save their discoverers.

34. Chemists have been in the habit of dividing the elements into two classes, metallic and non-metallic. The distinction serves a good purpose in discussion, but practically is of little moment, as no very well defined line can be drawn between them.

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35. Metals are good conductors of heat and electricity, while non-metallic elements are generally the reverse.

36. To save time in writing, each element is represented by a symbol, consisting of the first, or first and second letters of its name. Thus O stands for Oxygen, Si for Silicon. Some of the names are Latinized, and the first letter or two letters of the Latin name used; thus, Pb stands for Lead, Plumbum being the Latin word.

37. We shall take up the non-metallic elements first. They are thirteen in number. The following table gives their names, symbols, and equivalent numbers, omitting the fractions.

NAME.	SYMB.	E. NO.	NAME.	SYMB.	E. NO.
Oxygen . . .	O	8	Iodine	I	126
Hydrogen . .	H	1	Bromine . . .	Br	78
Nitrogen . . .	N	14	Fluorine . . .	Fl	19
Carbon . . .	C	6	Selenium . .	Se	40
Sulphur . . .	S	16	Boron	B	11
Phosphorus .	P	31	Silicon	Si	22
Chlorine . . .	Cl	35			

38. The preparation and management of gases are among the first difficulties which a young chemist encounters. Before commencing the study of Oxygen, it will be advisable, therefore, to introduce the learner to a few of his more important tools.

39. A spirit-lamp is necessary. It may be made of earthenware, tin, or glass; but glass is preferable, as it can be more readily seen when the lamp needs fuel. A common phial, with a metallic tube, will answer the purpose, if nothing better can be had. The fuel used is alcohol, which gives out considerable heat, and deposits no soot.

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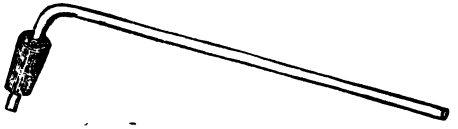
40. Flasks are often employed in the preparation of gases. Florence flasks, which come to this country with olive oil, may sometimes be had at grocers' stores for a trifle, and, on account of their thinness, stand the sudden application of heat very well. To prepare Oxygen, however, a wide test-tube, like the accompanying figure, made of hard German glass, or copper, is preferable.

41. Into the mouth of the test-tube fit a sound cork, through which a hole may be burned with a red-hot wire, and smoothed with a round file. This hole is for the passage of the conducting-tube, which is of glass, and should be as wide as possible, to allow ready exit to the gas. After passing the conducting-tube through, it may be brought to the required angle by holding it in the flame of the spirit-lamp, and gently bending it, like the following figure.



42. A pneumatic trough of some sort is also needed. Very neat ones of japanned tinplate may be had of philosophical instrument makers; but the beginner should himself make as many of the instruments he requires as possible. It is simply a square vessel, with a shelf fitted close to one side and both ends. The shelf should not be above one-third the breadth of the trough, placed about two inches from the top, and perforated with two or three small holes. Should the student, however, not wish to incur so much expense or labor, a basin, or little washtub, may be easily fitted up with a shelf, and serve the same purpose. The pneumatic trough is used in collecting the gas, as will be afterwards fully explained.

43. The bottle, or other vessel in which the gas is collected, is called a receiver. It stands over one of the holes in the shelf, upside down, and full of water.

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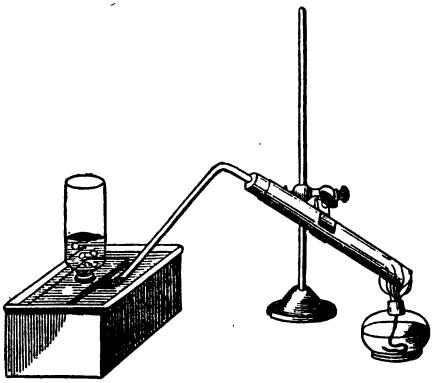
44. A support for the test-tube, called a retort-stand, is also a useful piece of apparatus, as without it we would require to hold the test-tube in our hand during the experiment. It should be fitted with a vice: the whole arrangement is shown below.



OXYGEN.

45. Oxygen is a colorless gas, without either taste or smell. When uncombined, it is only known in the gaseous state; all attempts to reduce it to the liquid form, by cold and pressure, having failed. Oxygen is the most abundant element in nature. It constitutes one-fifth of the atmosphere, eight-ninths of water, about one-half of the earth's mineral crust, and nearly one-fourth of dry albuminous compounds. Rays of light, in passing through it, are very slightly bent. It is a little heavier than atmospheric air, and on this account may be transferred from one vessel to another by "displacement." (See pars. 115, 132.) It is nearly insoluble in water.

46. Oxygen is the great supporter of combustion; all burning bodies consume with greatly increased brilliancy when plunged into an atmosphere of this gas. Light a splinter of pine, and after a few seconds blow out the

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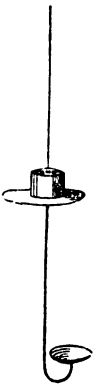
flame; then plunge the red-hot end into a bottle full of Oxygen, when it will be immediately rekindled with a slight explosion, and continue to burn very brightly and rapidly, until either it or the Oxygen in the bottle is exhausted. Similar experiments may be performed with Sulphur, Charcoal, Phosphorus, and fine Iron wire. The charcoal used for this purpose should be made from hard, barky wood, and suspended, by means of a copper wire cage, in the spirit-lamp, until red-hot, before being plunged in the gas. When fine steel wire is used, it may be twisted like a screw by winding it round a thick pencil; straighten each end, dip one into melted Sulphur, and fasten the other to a stout wire. On igniting the sulphur-end, and introducing it into a bottle of Oxygen, the wire is brought to a red heat, which commences the combustion. In a sufficiently large vessel, the wire is entirely consumed, giving out beautiful scintillations as combustion proceeds. Sulphur and Phosphorus may be burned in a deflagrating spoon like that in the margin. Sulphur should have a sharp edge, and may be lighted with the aid of a blowpipe before insertion. Phosphorus should be used in single pieces no larger than half a pea, and is easily set on fire with a hot wire.



47. Combustion consists in the chemical union of Oxygen with the burning body. Carbonic Acid and Water are the ordinary products of combustion. After combination with the elements of a burning body, Oxygen loses its power of supporting combustion. Thus, in the first experiment, if a lighted taper be introduced after all the Oxygen has combined with the burning wood, it will be extinguished.

48. The presence of Oxygen is essential to respiration. No animal can live in an atmosphere entirely deprived of Oxygen; and, as the act of breathing continually uses up a certain quantity, hence the necessity for a constant supply. If a mouse be placed in a sealed vessel of atmospheric air (which contains free Oxygen), it will live only so long as the supply lasts; when it is exhausted,

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the mouse dies. Were a lighted candle lowered into this jar after the animal's death, it would be extinguished. We may set it down a sa safe axiom, that, when an atmosphere cannot support the combustion of a candle, it is equally unable to support respiration.

49. An atmosphere entirely composed of Oxygen is also unfit for continued respiration. It would quicken unnaturally the circulation of the blood, and excite the whole system beyond endurance. Such an atmosphere would prove equally dangerous as far as combustion was concerned. Every thing which approached a red heat would take fire; our fuel would burn away with ruinous rapidity; and accidental fires could be put out only by destroying the adjacent houses.

50. As already remarked, Oxygen forms part of the air we breathe; but no process has been discovered for separating it in a gaseous form from the Nitrogen with which it is there associated. For experimental purposes, Oxygen is always procured from some one or other of its solid compounds.

51. When wanted pure, Chlorate of Potash is the salt employed. If a sixth part of Oxide of Copper be mixed with it, the gas will be much more readily given off. Powder the Chlorate of Potash, and heat the mixture for a minute or two, in an iron spoon, to expel moisture; then put it into a wide test-tube, using the apparatus already described. Fill the pneumatic trough with water till the shelf is covered at least half an inch deep; fill the receiver also with water; then, keeping the mouth downwards, lift it on to the shelf, over one of the holes. Apply heat by means of the spirit-lamp to the test-tube; in a few minutes, Oxygen gas comes off rapidly; but the first portion should be allowed to escape, as it is mixed with atmospheric air present in the apparatus. The extremity of the conducting-tube is then placed below the receiver; gas passes up, and displaces the water in it. When full, it may be removed on a common breakfast plate, surrounded with a little water to prevent escape of gas.

52. Oxygen may also be prepared from the Binoxide of Mercury, Nitrate of Potash, or Binoxide of Manganese. The last is used when a large quantity of gas is wanted.

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The black powder is heated to redness in an iron bottle, to which an iron conducting-tube is attached.

53. Oxygen forms compounds with all the elements, except Fluorine. The act of combining with Oxygen is called oxidation, and the compounds thus formed are oxides and acids. Oxidation always takes place during ordinary combustion; and the elements of the burning body are said to be oxidized. When one equivalent of Oxygen unites with a metal, &c., the compound is called protoxide; two equivalents, binoxide; and so on, Latin or Greek prefixes denoting the number of equivalents in combination with the substance.

54. The name is derived from two Greek words, *οξυς, acid*, and *γενναειν, to generate*, from a supposition of Lavoisier that it is the sole cause of acidity.

HYDROGEN.

55. Hydrogen is a gas; colorless, tasteless, and inodorous, when pure; but, prepared from Iron or Zinc in the usual way, it has a characteristic disagreeable smell. Next to Oxygen, perhaps, Hydrogen is the most abundant element. It forms one-ninth part of water; enters into the composition of many gases and minerals; and forms about seven per cent of dry albuminous substances. It is a powerful refractor of light; and is even more insoluble in water than Oxygen.

56. Hydrogen is a combustible, but not a supporter of combustion; that is to say, it can be burned itself, but other burning bodies are extinguished in it.

57. Hydrogen is the lightest body known, being about fourteen times lighter than common air. On this account, it is the best material for filling balloons. The gas should be previously dried, by attaching a bottomless eau de Cologne bottle, containing Chloride of Calcium, to the connecting-tube; and fixing a second tube to the other end of the Cologne bottle, to which tube the balloon may be tied. A simple way of showing the lightness of Hydrogen is to fill a bladder with the gas, and blow soap bubbles, which ascend very rapidly. (See par. 63.)

58. Hydrogen cannot support respiration. Animals placed in an exclusive atmosphere of this gas almost in-

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stantly die. Death does not ensue from the gas being used up, nor from any peculiar poisonous property, but from Oxygen being absent; for an atmosphere composed of Hydrogen and Oxygen, in equal measures, may be respired with safety.

59. Hydrogen is prepared by decomposing water; a metal which is readily oxidized being chosen for that purpose. Take a wine bottle, and fit it with a cork and bent tube. Add half an ounce of Sulphuric Acid, in successive portions, to six ounces of water, and allow it to cool; then put an ounce of Zinc, clipped small, into the bottle. Gas is immediately disengaged, and may be collected in the same way as detailed in par. 51. No heat requires to be applied in this operation.

60. Iron turnings may be used instead of Zinc; but the gas evolved from Iron is never so pure, and has a more disagreeable odor. When filings are employed, the materials froth up, and annoy the experimenter. Zinc may be granulated by melting it in an iron ladle, and pouring it from a height into water.

61. Water being composed of Oxygen and Hydrogen, the former unites with the Zinc, and Hydrogen is set free. The Sulphuric Acid dissolves the coating of Oxide as soon as formed, and thus presents a fresh surface for oxidation.

62. A number of interesting experiments may be performed with Hydrogen; but they all require the exercise of great care and prudence. When mixed with atmospheric air, in certain proportions, it forms a highly explosive mixture. The utmost caution, therefore, must be taken to ensure the absence of air from the receiver, by filling it quite full of water, and also allowing the first portions to escape before proceeding to collect the gas.

63. To show the extreme lightness of Hydrogen, fill a bladder with it by the following simple method: — Apply a red-hot iron to the lower rim of a common bottle. It will crack; and, after repeated applications, leading the crack all round, on plunging it into cold water the bottom will fall off. Fit a cork (with a piece of tube throughi and a small cork in the tube) into the neck of the bottle and, having moistened the bladder and pressed out the air, tie it firmly to the tube. Gas may be collected in

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this bottomless bottle, by filling it with water in the usual way. When full of gas, pull the small cork out (which can easily be done through the folds of the wet bladder), and transfer the gas to the bladder by simply depressing the bottle in water. Another string is then tied round the neck of the bladder, higher up than the tube; the first string is loosed, a tobacco-pipe tied in, and the whole is ready for action. After inserting the pipe-bowl into soap-suds, and loosing the second string, press out gas, by placing the bladder under your arm. The bubbles, which rise rapidly, may be inflamed by a second person as they ascend, taking care that he does not set fire to them until fairly detached.

64. Fill a small, wide-mouthed bottle with Hydrogen, and, having covered its mouth under water with a piece of greased plate glass, hold it inverted in your left hand; and, while an assistant rapidly withdraws the cover, introduce a lighted taper on a wire. The taper will be extinguished, while the gas itself will burn at the mouth with a yellowish-blue flame.

65. If a brass tube, with a fine jet, be attached to a bladder of Hydrogen, and the gas directed upon spongy Platinum, the metal immediately becomes red-hot, and sets fire to the gas. This discovery was made by Prof. Doebereiner; and a lamp for giving an instantaneous light is now manufactured on that principle.

66. When one part, by measure, of Oxygen is added to two of Hydrogen, in a strong bottle, and the mixture inflamed, a loud explosion occurs, and Water is generated. This is rather a dangerous experiment, and should not be attempted by a novice. The bottle should be small, and wrapped round with several folds of a towel; or a stout tin cylinder may be used instead of the bottle.

67. The name is made up from *ὑδωρ*, *water*, and *γενναειν*, *to generate*.

WATER.

68. Water is a compound body, composed of the two elements we have already considered, in the proportion of 8 parts, by weight, of Oxygen to 1 of Hydrogen; or, by measure, of one part Oxygen and two Hydrogen.

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69. It may be remarked, that gases combine in definite proportions *by measure*, as well as by weight. When two gases combine in equal measures, the resulting body occupies the same space that its elements did before combination; but, if they unite in unequal measures, condensation always takes place. Thus, one pint of Hydrogen unites with one of Chlorine, forming two pints of Hydrochloric Acid gas; and two pints of Hydrogen unite with one of Oxygen to form two pints of Water (in vapor).

70. Pure Water is said to be without color, taste, or smell; but these are not its common properties. As found in nature, it is always more or less mixed with impurities, and it may be owing to their presence that water has a taste, though not a very marked one. We are all familiar with the bluish-green color of the ocean; and it is a fact well authenticated, that camels can scent a spring of water many miles distant. Water is elastic only in a very slight degree. At 32° of Fahrenheit's thermometer, water freezes; and at 212°, it boils. These two numbers are called the freezing and boiling points of water, and serve as guages in dividing the thermometer scale. A cubic inch of water, at the temperature of 60°, weighs 252 grains; a fluid ounce, 437.5 grains; a gallon, 70,000 grains or ten pounds avoirdupois.

71. Water in freezing undergoes a very great expansion. The bursting of water-pipes, during frosty weather, is a familiar example. In this respect, it forms a remarkable exception to the laws of heat. Bodies, in general, expand with heat and contract with cold. But water expands both below and above 40°. At that temperature, therefore, it is at its maximum point of density; or, in other words, its particles lie closest. This is a beautiful provision. When ice forms on the surface of water, it floats; whereas if, contracting, it became heavier and sank, layer after layer of ice would be formed, each sinking in its turn, until the whole became one solid mass, and our longest summers would be too short to thaw it.

72. When converted into steam, water occupies nearly seventeen hundred times its former bulk.

73. About three-fourths of the globe's surface are covered with water; and the extent to which it enters into the composition of vegetables and animals will scarcely

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be credited. Prof. Johnston, of Durham, states, that "potatoes contain about four-fifths of their weight of water, or five tons of roots contain nearly four tons of water. Turnips contain sometimes upwards of nine-tenths of their weight of water." Blood contains about four-fifths of its weight of water; and, what is remarkable, lean flesh contains nearly as much.

74. The composition of Water may be proved by passing dry Hydrogen gas over Oxide of Copper heated to redness. The Oxygen and Hydrogen unite, forming Water, and metallic Copper is left. Or, what is more easily performed, hold a dry glass vessel over a burning jet of Hydrogen, for a few seconds, when Water will bedew its inner surface, produced by the burning gas combining with the Oxygen of the air.

75. Water is the most extensive solvent with which we are acquainted. It is on this account that we never meet with ordinary water in a state of chemical purity. Rain falls upon the ground, penetrates below the surface, and dissolves out the soluble matter with which it comes in contact. It is in this way that much nourishment is carried to the roots of plants. Water also absorbs gases in variable quantities. Unboiled water always contains atmospheric air, without which, indeed, it would taste very insipid; and some springs, as at Saratoga, contain a large quantity of Carbonic Acid. Water already saturated with one gas, on being exposed to a second, gives out a portion of the first gas, and absorbs the second. A glass of soda-water may be made to re-effervesce by simply striking the rim with the palm of the hand. Common air is forced in, and Carbonic Acid escapes.

76. Warm water, in general, dissolves more of a given substance than cold water. Thus, sugar is more soluble in hot than cold water. Lime and common salt are the more marked exceptions. Lime is more soluble in cold than warm water, and common salt is alike soluble in both. The great majority of combustible bodies are insoluble in water. Alcohol is the chief exception.

77. Sea-water contains a large quantity of soluble salts; hence its high specific gravity. This quantity varies in different places, and even in the same place at

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different times: the following is an approximation in 1000 parts: —

Water	965.0
Common salt	27.5
Salts of Magnesia	6.0
Sulphate of Lime	1.5
	1000.0

Mineral waters are those which abound in Sulphate of Magnesia, Iron, Lime, Sulphuretted Hydrogen, Carbonic Acid, &c.

78. Lead is an impurity often contained in the water of populous towns, from the circumstance of its passing through Lead pipes for a considerable distance. There are two circumstances favorable to its solution; namely, that the water be tolerably pure, and have access to air. That Lead is more soluble in pure water may be proved by a simple experiment. Place a piece of bright Lead in a bottle of distilled water which has been some time exposed to the atmosphere, and a similar piece in a bottle of spring water in which a little Phosphate of Soda has been dissolved. Four or five days afterwards, the pieces of Lead may be taken out, and the water in both bottles examined. Sulphuretted Hydrogen is a "test" for Lead; and, on passing that gas through the distilled water, a brownish-black precipitate is formed; whereas no change takes place on passing it through the spring water. In the first instance, the Lead is covered with a white film, which the water dissolves, thus exposing a fresh surface, and the process of coating and dissolving goes on; but, in the bottle of spring water, an insoluble film is formed on the surface of the Lead, which protects it. Rain-water cisterns should not be lined with Lead. Its solution in water to any considerable extent must be highly injurious to health.

79. For dissolving salts intended to be used as tests, washing analytical apparatus, and indeed for any experiment where accuracy is required, Distilled Water is taken. The process for preparing it consists in boiling water, and condensing the steam. Attach a glass tube to a Florence flask, keeping the tube cool with wet cloths. Or a tube may be inserted into the spout of a tea-kettle,

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care being taken that the water does not cover the internal opening. Distilled water, as soon as prepared, should be kept in a well-stoppered bottle; otherwise, it speedily absorbs Carbonic Acid from the atmosphere.

80. The equivalent number of Water is 9; symbol, HO. It will be observed that the equivalent number of a compound body is got at by adding together the equivalent numbers of its elements. Symbols of compound bodies are made up in the same way.

NITROGEN.

81. Nitrogen is a gas, and distinguished more for its negative than its positive properties. It has neither color, taste, nor smell; it is neither acid nor alkaline; and is nearly insoluble in water. It is a little lighter than common air.

82. Nitrogen is neither combustible nor a supporter of combustion; and it is equally incapable of supporting respiration. It does not prove fatal, however, from inherent poisonous properties, but solely by excluding Oxygen.

83. Nitrogen constitutes four-fifths of the atmosphere; enters into the composition of many gases and minerals;

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and forms about fifteen per cent of dry albumen. It is present more abundantly in animal than in vegetable tissues.

84. Nitrogen may be readily prepared by burning Phosphorus in a jar of atmospheric air inverted over water. The Phosphorus combines with the Oxygen of the air, and Nitrogen gas is left. Fill a deep plate with water, on which float a watch-glass. Place on this a pea of Phosphorus, and set fire to it. Then place a receiver over it, and allow the whole to stand until the white fumes are absorbed. You will now find that the water has risen in the jar so as to occupy one-fifth, which space corresponds to the quantity of Oxygen abstracted. To avoid accidents, Phosphorus should always be cut under water.

85. Having prepared your gas, transfer it to a bottle by inverted decantation, and introduce a lighted taper; it will be immediately extinguished.

86. While the wick is still red-hot, plunge the taper into a bottle full of Oxygen, and it will be rekindled. This amusing experiment may be repeated several times, alternately introducing the taper into bottles of Nitrogen and Oxygen.

87. Nitrogen is also called Azote, from *α, to deprive of*, and *ζωη, life*. The word Nitrogen means *to generate nitre*.

88. Besides entering into the composition of atmospheric air, Nitrogen forms five definite compounds with Oxygen. The following are their names, equivalent numbers, and symbols: —

Protoxide of Nitrogen	22	. . . NO
Binoxide of Nitrogen	30	. . . NO_2
Hyponitrous Acid	38	. . . NO_3
Nitrous Acid	46	. . . NO_4
Nitric Acid	54	. . . NO_5

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The preceding table is an illustration of the third rule of chemical combination. It will be observed, that in all these compounds the amount of Nitrogen remains the same, namely, one proportion; while the Oxygen increases in the exact ratio of two, three, four, and five simple multiples. The symbol of any substance also denotes one proportion of it. A small figure placed to the right refers to the proportions of the symbol immediately preceding it. A large figure placed to the left multiplies all the symbols which follow, on to the first comma or plus. Thus, $3\,NO_5$ means three equivalents of Nitric Acid.

89. Protoxide of Nitrogen, or Nitrous Oxide, — also called Laughing gas, — has an agreeably sweetish taste, and is colorless and inodorous. By cold and pressure, it may be converted into a liquid. Recently boiled water, after cooling, dissolves its own bulk of the gas. It is a good supporter of combustion. A candle with a large red-hot wick is rekindled when plunged into Protoxide of Nitrogen. It may be distinguished from Oxygen by its taste, and ready solubility in water.

90. When breathed for two or three minutes, Nitrous Oxide produces a peculiar kind of intoxication, which soon goes off, and is not generally followed by depression. In persons of a plethoric habit, it sometimes causes headache.

91. Nitrous Oxide is prepared by decomposing Nitrate of Ammonia. One ounce of that salt is put into a retort, and heat applied with a spirit-lamp. After a short time, the salt fuses, and latterly is decomposed, forming Water and Nitrous Oxide, both of which pass off, leaving the retort empty. The fused salt should only be kept simmering.

92. Binoxide of Nitrogen, or Nitric Oxide, is a colorless gas, without taste or smell. It is distinguished by the circumstance of orange-red vapors being produced when atmospheric air is admitted into the vessel in which it is contained.

93. Binoxide of Nitrogen supports the combustion of Phosphorus or Charcoal. It is not combustible alone; but, when mixed with an equal bulk of Hydrogen, it burns with a light green flame. Undiluted, it is altogether

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irrespirable. Diluted to a certain extent, it may be inhaled; but it is highly poisonous. It is sparingly soluble in water.

94. Binoxide of Nitrogen may be prepared from Nitric Acid and Copper. The acid, diluted with its own bulk of water, is poured upon scraps of Copper in a glass retort. Effervescence takes place at first without applying heat; gas comes off, the metal is dissolved, and a blue liquid results. The beak of the retort should be kept under water all the time, but only colorless gas collected. Heat is needed in the later stages.

95. Hyponitrous and Nitrous Acids are involved in some obscurity. The former is interesting on account of playing a part in the manufacture of Sulphuric Acid. The ruddy fumes which arise on adding atmospheric air to Binoxide of Nitrogen are fumes of Nitrous Acid.

96. Nitric Acid, or Aquafortis, has been found in the atmosphere in minute quantities, after thunder-storms. It exists abundantly, in combination with Potash or Soda, as an ingredient of soils; and it is also met with in the sunflower and other plants.

97. Nitric Acid has never been isolated. It must be combined with something else; and the simplest form to which it can be reduced is that of a hydrate. In this state it is a colorless liquid when pure, emits white fumes on taking out the stopper of the bottle, and has an intensely sour taste. Its highest specific gravity is 1.52. Commercial acid has a yellow tinge, due to the presence of Nitrous Acid, and contains more water.

98. Nitric Acid is a powerful oxidizer, and in this way dissolves most of the metals. The oxidation is most rapid when a moderately dilute acid is employed. It rapidly destroys animal tissues; and the slightest touch leaves a yellow stain on the skin. It freezes at 50° below zero. Direct solar light decomposes it; so that the pure acid should be kept in dark-colored bottles, or otherwise protected from the action of light.

99. Into a green glass retort put an ounce of nitre, previously dried and powdered; pour on this an ounce of Sulphuric Acid, and, having adapted a receiver, apply heat. The receiver may be kept cool by covering it with a cloth kept moist by water trickling from a tunnel. The

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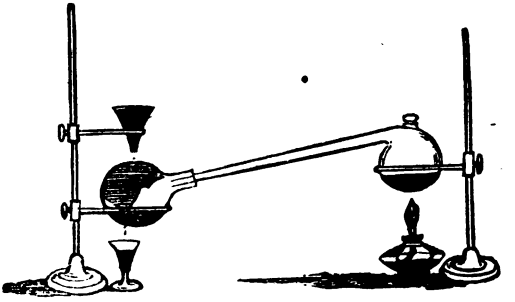
acid should be slowly poured upon the nitre, taking care to avoid the fumes; and a moderate temperature steadily maintained throughout. At the commencement and towards the close of distillation, red fumes are given off, which impart a yellow color to the liquid in the receiver. This liquid is Nitric Acid. Sulphate of Potash is left in the retort.



100. Commercial Nitric Acid often contains Sulphuric, and sometimes Hydrochloric Acid. These impurities may be detected by using the tests given under their respective heads.

101. TESTS. — 1. A drop let fall on Morphia produces a blood-red color. 2. The yellow stain it imparts to the nails or any organic tissue. All the salts formed with Nitric Acid are soluble in water, and on this account we have no precipitate-test.

THE ATMOSPHERE.

102. The Atmosphere, or air which surrounds our globe, is not a chemical compound, but merely a mechanical mixture. It is composed, by measure, of four parts Nitrogen to one Oxygen, along with a minute quantity of Carbonic Acid and watery vapor. It extends at least forty miles in every direction, and presses upon the earth's surface with a force equal to fifteen pounds on the square inch.

103. Common air is tasteless, invisible, inodorous, and

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but sparingly soluble in water. At the temperature of 60°, one hundred cubic inches weigh thirty-one grains. It is 815 times lighter than water, and is the standard of specific gravity for gases.

104. Atmospheric air is easily compressed, and highly elastic. This may be shown by blowing air into a narrow-necked bottle, closing the aperture with our tongue, and then suddenly withdrawing it, when air may be heard rushing out. It is this elasticity of air which causes it to penetrate and fill up every unoccupied crevice in the earth and the bodies on its surface.

105. As the air of itself has weight, and is forty miles high, those parts which are uppermost must press upon those below, and force the particles closer together.

106. The pressure of the atmosphere hinders fluids from boiling. When we remove this pressure, therefore, any liquid may be made to boil at a much lower temperature than under ordinary circumstances. To perform this experiment, an air-pump is generally employed; but those who cannot procure this expensive instrument may illustrate the subject by forming a vacuum with condensed steam. Take a Florence flask one-third full of water, and apply heat until steam issues freely. Then close the mouth with a sound, tight-fitting cork. After ebullition has entirely ceased, but while the water is still warm, it may be made to boil again by sprinkling the flask with *cold* water; the explanation of which is as follows: After the water has ceased boiling, the upper part of the flask is filled with steam instead of air; and, on applying cold, this steam condenses. As all external communication is cut off by the cork, a vacuum must be produced; and, the pressure being thus removed, the heat still retained by the water is sufficient to cause re-ebullition.

107. A similar experiment consists in boiling water in a stout flask, corking it, and, after the whole has become cold, taking the cork out under water, when the latter rushes in with explosive rapidity. The operator's hands should be protected with gloves.

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108. The pressure of the atmosphere causes water to rise in pumps. Water cannot be pumped directly from a greater depth than thirty-four feet; a column of water that length being as much as the atmosphere can support. For the same reason, Mercury cannot be pumped higher than thirty inches.

109. Carbonic Acid forms a constant ingredient of atmospheric air in the proportion by measure of 1 part in 2000; and also watery vapor in variable proportions, say 10 parts in 1000. When air is too dry, the skin becomes hard, and the insensible perspiration is checked. On the other hand, when air is overcharged with moisture, absorption is preternaturally quickened, and the system more exposed to injury from infectious miasma.

110. A great number of other vapors and gases must also be present in the atmosphere, but in quantities so small as to elude analysis. Of this nature are effluvia from marshes, gases emitted by volcanoes, &c.

111. Respiration and combustion produce important changes on the atmosphere. Its Oxygen unites with Carbon, forming Carbonic Acid; and with Hydrogen, forming Water. Unless, therefore, the air be regularly changed in an apartment where these two processes are going on, its Oxygen will at length be used up, and both put a stop to. Currents in the atmosphere, its great extent, and the compensatory action of plants, keep it, as a whole, in a state of purity.

AMMONIA.

112. Ammonia is a compound of Nitrogen and Hydrogen. It is a colorless, invisible gas, with a pungent smell (by which it is readily distinguished), and a biting, caustic taste. Ammonia cannot be formed by the direct union of its elements; but is abundantly produced during the decomposition of organic matter. Put a few cuttings of quill tops into a test-tube, and apply heat with a spirit-lamp. As the process of decomposition goes on, Ammonia is generated, and may be detected by its characteristic odor. It is produced in immense quantities at gas-works during the destructive distillation of coal; and it is the chief compound of value in guano.

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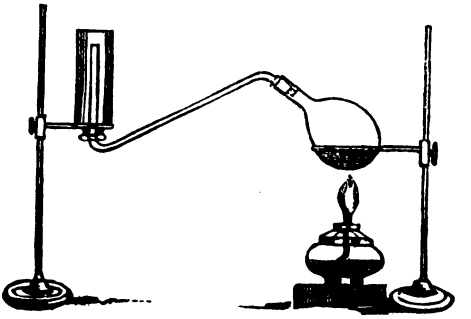
113. Ammonia is not a supporter of combustion; nor is it combustible in common air. It is irrespirable. Its specific gravity is 0.59, or about half that of the atmosphere. Under the influences of cold and pressure, it may be liquefied. It is remarkable for its solubility in water: one pint will absorb 780 pints of the gas.

114. Ammonia is an alkali, and possesses in a marked degree the properties that characterize these substances. Thus, alkalies render turmeric paper brown; and if we moisten a piece of this paper with water, and hold it in a current of the gas, its yellow color will be changed to brown. Ammonia has been called the volatile alkali, on account of the fleeting nature of its effects. Take the piece of turmeric paper which has had its color changed, and, on exposing it to a gentle heat, the original color returns.



115. To prepare Ammonia, take equal parts of recently burned Lime and Hydrochlorate of Ammonia. Slake the Lime with warm water, and cover it up, while you reduce the Hydrochlorate of Ammonia to powder. Then rapidly mix the two, put them into a Florence flask, and apply heat as long as the gas is given off. From its extreme solubility in water, it is impossible to collect it in the usual way; but it may be collected by "displacement," which simply consists in holding an inverted bottle over

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the conducting-tube, when the gas ascends and displaces the air. The peculiar odor of Ammonia tells us when the bottle is full.

116. Fill a small stoppered bottle with Ammonia, and take out the stopper under water. The water will rush into the bottle instantaneously. Immerse a piece of turmeric paper in this water, which will show that it is alkaline. "Hartshorn" is a solution of Ammonia in water; and may be prepared with the above apparatus by reversing the tube and receiver, and filling the latter with cold distilled water.

117. TESTS. — 1. Its peculiar odor. 2. Dip a glass rod in Hydrochloric Acid, and hold it over a solution of the gas, when dense white fumes will be produced.

118. The name Ammonia was derived from the circumstance of sal ammoniac being first prepared from camels' dung found near the temple of Jupiter Amnon.

119. The equivalent number of Ammonia is 17; symbol, NH_3.

120. Ammonia combines with acids, and forms compounds analogous to those formed with Potash and Soda, the more important of which are — Hydrochlorate, Carbonate, and Nitrate of Ammonia.

121. HYDROCHLORATE OF AMMONIA, or Sal Ammoniac, is manufactured from the ammoniacal liquor of coal-gas works, and purified by sublimation. It is a tough, odorless solid, with a fibrous texture internally. Symbol, NH_3HCl.

122. CARBONATE OF AMMONIA, or Smelling salts, is prepared on the large scale by heating sal ammoniac with dry chalk. When recently made, it is hard and semi-transparent; but, when exposed for some time to the air, it loses Ammonia, becomes opaque, and crumbles down. It has a pungent odor. Symbol. $2NH_3, 3CO_2 + 2HO$.

123. NITRATE OF AMMONIA is prepared by adding Nitric Acid, in successive small portions, to a solution of the Carbonate as long as effervescence takes place. On evaporating the solution till a thin film forms on the surface, and then setting it aside to cool gradually, long needle-shaped crystals may be obtained. This is a deliquescent salt, and must therefore be preserved in well closed bottles. Symbol, $NH_3NO_5 + HO$.

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CARBON.

124. Carbon forms a considerable part of limestone and other minerals. It is the solid element left after heating dry vegetable or animal substances in close vessels, constituting about one-half of their weight; and, in the shape of Carbonic Acid gas, it occurs in the atmosphere.

125. Charcoal, prepared from wood, is the most common variety of Carbon; but its purest form is the Diamond. It is also found in the shape of Plumbago or "black lead." The best pencils do not contain a particle of Lead, but are nearly pure Carbon. Animal charcoal and Ivory black, made from bones or blood; Lamp-black, from tar; and Anthracite coal, are all varieties of this element.

126. Carbon is remarkable for its indestructibility; resisting the most intense heat, if kept in close vessels; and its disappearance, when heated in the open air, is due to combination, not volatilization. This explains the fact, that the more Carbon an organized body contains, so much the less liable is it to decomposition.

127. Wood charcoal is particularly distinguished for its great power in absorbing gases. A drooping plant may be revived by sprinkling charcoal powder around it, because charcoal absorbs gases of which the plant stands in need. Animal charcoal has the property of absorbing coloring matters, and is employed for this end by sugar refiners. In this process, it acts mechanically, and, after being heated to redness, may be used again. Charcoal is anti-putrescent, and also removes the odor from tainted meat after putrefaction has commenced. Foul water may be purified by filtration through animal charcoal. Carbon is a good conductor of electricity.

128. Carbon forms two compounds with Oxygen; namely, Carbonic Oxide and Carbonic Acid.

129. CARBONIC OXIDE is a poisonous gas, inflammable, colorless, and inodorous. It is neither acid nor alkaline; nor is it a supporter of combustion. Specific gravity, 0.972, or nearly that of atmospheric air.

130. To prepare Carbonic Oxide, take two hundred grains of crystallized Oxalic Acid (C_2O_3, 3HO) and three

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drams of Sulphuric Acid, in a small retort, and apply gentle heat. The pneumatic trough and receiver may be filled with lime-water, to absorb the Carbonic Acid which is generated at the same time. Eq. number, 14; symbol, CO.

131. Carbonic Acid is a colorless gas at ordinary temperatures, but may be reduced to the liquid and even the solid state. It has an acid taste; it is not combustible, nor can it support combustion. A lighted candle is extinguished in a mixture of four parts common air to one Carbonic Acid. It is also incapable of sustaining respiration, and this, too, on account of an inherent narcotic property. When atmospheric air contains twelve per cent of this gas, it is quite unfit for respiration. Specific gravity, 1.5.

132. Any of the Carbonates may be used in preparing it. Put a few marble chips into a common bottle fitted with a lead or glass tube, cover them with water, and pour on Hydrochloric Acid. Gas is liberated abundantly without applying heat, and may be collected by downward displacement.

133. Carbonic Acid often accumulates at the bottom of old wells, and causes many accidents. Before going down, a lighted candle should be lowered; if put out, it would be dangerous to descend until the place is purified. This may be done by throwing in wet Lime. It is Carbonic Acid which communicates the agreeable pungency to beer, wine, soda-water, &c.; for although poisonous when breathed, it may be taken into the stomach with comparative safety.

134. Carbonic Acid is generated in the processes of respiration, combustion, fermentation, and decay.

135. Test. — Take a bottle of the gas, and agitate it with lime-water. A cloudy precipitate (Carbonate of Lime) is formed. The lime-water should be plentifully added, because Carbonate of Lime is soluble in an excess of Carbonic Acid. This test also distinguishes the gas from Nitrogen, which is not affected by lime-water.

136. The equivalent number of Carbonic Acid is 22; symbol, CO_2.

137. Coal Gas. — In the year 1664, Dr. Clayton made the important discovery, that an illuminating gas could

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be got from coal by heating it. In 1792, Mr. Murdoch directed his attention to the practical application of this discovery; and, after six years of hard labor, succeeded in erecting gas apparatus to light the workshops of Boulton and Watt, near Birmingham. Mr. Clegg invented the hydraulic main, — a wide tube, kept about two-thirds full of tar, into which the pipes leading from the retorts dip. This gentleman also invented the wet lime purifier and the common gas meter. Gas was employed for street illumination, in London, for the first time in 1812.

138. Coal gas is a mixture of several gases and vapors, the principal of which are — Light Carburetted Hydrogen (CH_2), Olefiant gas (C_2H_2), Benzole (C_2H), Carbonic Oxide, and Hydrogen. It is prepared on the large scale by distilling cannel coal, at a cherry-red heat, in fire clay or iron retorts. Tar, ammoniacal liquor, and naphtha, also distill over, and are collected in a hole under ground. The gas is first passed through a series of tubes surrounded with water, called the condenser, to cool it and to separate portions of tar which are carried over in the state of vapor. After passing through the condenser, coal gas still contains Ammonia, Sulphuretted Hydrogen, and Carbonic Acid; and, in order to separate these deleterious gases, it is passed through an apparatus containing slaked lime on shelves. The gas is finally stored in the gasometer, — a large, bottomless cylinder of sheet iron, suspended in water. Coal gas, manufactured at a high temperature, is used to fill balloons.

SULPHUR.

139. Sulphur exists in the albumen, fibrine, and casein both of plants and animals; as Sulphate of Lime in some plants; and very extensively in earthy masses, near volcanoes. It is also found combined with metals, the compounds with which are called Sulphurets. Vast quantities of Sulphur are annually exported from Sicily, where it occurs in beds of blue clay. It is partially purified by fusion, and more completely by sublimation. After undergoing the latter process, it is called "flowers of sulphur." In Cornwall, large quantities are prepared from the Sulphurets of Iron and Copper.

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140. At ordinary temperatures, Sulphur is a tasteless and brittle solid, of a pale yellow color. A roll of it held firmly in the hand gives out a crackling sound, and breaks. When rubbed, it emits a peculiar odor. Exposed to heat, a portion passes off in vapor; and, as the heat increases, the remainder becomes liquid, and flows freely. In a short time, it becomes of a viscid, gluey consistence, and the color changes to a dark-red; but, on raising the temperature still further, it again becomes fluid. Sulphur is highly combustible, burning with a blue flame. It is insoluble in water; oil of turpentine and Bisulphuret of Carbon are its best solvents. Sulphur is used as a medicine; and in the manufacture of gunpowder, vermillion, and Sulphuric Acid. Specific gravity, 1.99.

141. Sulphur forms two important compounds with Oxygen; namely, Sulphurous and Sulphuric Acids.

142. Sulphurous Acid is a gas, and is always formed when Sulphur is burned in atmospheric air. It may be readily prepared by pouring strong Sulphuric Acid on Copper, and applying heat. The Copper is oxidized, and Sulphurous Acid gas given off, which may be collected by displacement.

143. Sulphurous Acid is colorless; it has a peculiar odor, and a weak acid taste. One pint of distilled water absorbs thirty-three pints of the gas. It is a mild bleaching agent, and is extensively made use of in bleaching straw plait for bonnets. Sulphurous Acid bleaches by combining with the color, not by destroying it. If we take a red rose, and hold it over burning Sulphur, in a receiver, its color soon disappears; but it may be in great part restored by dipping the rose into a strong alkaline solution. At zero, under the ordinary atmospheric pressure, it can be reduced to the liquid form, in which state it is remarkable for volatility and the extreme cold attained during its evaporation, — a temperature low enough to freeze Mercury. Specific gravity of the gas, 2.21. Equivalent number, 32; symbol, SO_2.

144. Sulphuric Acid, or Oil of Vitriol, is best known as a heavy, oily liquid, possessing powerful corrosive properties. Aided by heat, it can decompose vegetable and animal substances of every kind, reducing them to

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charcoal and water. Its action on organic bodies chiefly depends on its strong attraction for water.

145. Sulphuric Acid is prepared by burning Sulphur in contact with Nitrate of Soda, and collecting the gases in a large chamber made of lead, into which steam is also introduced. Water, slightly acidulated, occupies the bottom of the chamber, and this process is continued until the liquid attains a specific gravity of 1.6, when it is drawn off, and concentrated, first in shallow leaden pans, afterwards in a platinum still. In this state, it contains one equivalent of water, and its specific gravity should not be higher than 1.85.

146. Sulphate of Iron (green vitriol) is employed in the manufacture of Sulphuric Acid at Nordhausen. This salt is thoroughly dried on an open fire, and then exposed to a red-heat in earthen retorts. Nordhausen acid has a brown color, approaching to black, and emits fumes on exposure to the air. It is principally used in dissolving indigo. Specific gravity, 1.90.

147. Place two or three ounces of the common acid in a shallow basin. It will rapidly absorb moisture from the air, so that its bulk may be nearly doubled in a few days. On account of possessing this property, Sulphuric Acid is sometimes employed by chemists to dry gases.

148. The sudden combination of Water with Sulphuric Acid gives rise to great heat. Add two fluid ounces of acid to one of water, in a thin flask, and stir well. The temperature rises above the boiling point of water. In diluting Sulphuric Acid, it is better to use an earthen vessel, beeause those made of thick glass are very liable to crack.

149. Anhydrous Sulphuric Acid may be procured from the Nordhausen acid by introducing it into a capacious retort, connected with a cooled receiver, and applying heat. One portion remains in the retort along with the combined water, while the other condenses in the receiver. As thus prepared, it is a white, silk-like solid, tough and elastic, volatile, and, what is very remarkable, has no acid properties.

150. Many thousand tons of Sulphuric Acid are every year manufactured in Britain and America. By successive improvements, it has been gradually reduced in

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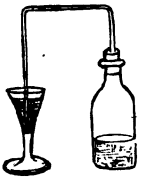
price, and in this way helps to cheapen many articles of home consumption in the manufacture of which it is employed, as soap, glass, starch, printed cloths, stearine candles, &c. Equivalent number, 40; symbol, SO_3.

151. Test. — A solution of Chloride of Barium throws down a dense white precipitate (Sulphate of Baryta), insoluble in all acids and alkalies.

152. Hydrosulphuric Acid, or Sulphuretted Hydrogen, is composed of Sulphur and Hydrogen. It is a colorless gas, with an extremely offensive odor, resembling rotten eggs. It is not a supporter of combustion, but is itself combustible. Cold water absorbs its own bulk of the gas: cold and pressure convert it into a liquid. Specific gravity, 1.7.

153. Hydrosulphuric Acid causes instant death when breathed. Air containing one fifteen hundredth part of the gas killed a small bird, and a horse died in an atmosphere containing the two hundred and fiftieth part of its bulk. This gas exists in some mineral waters, where it may be recognized by its peculiar odor; and it is generated during putrefaction.

154. Hydrosulphuric Acid is best prepared from Sulphuret of Antimony and Hydrochloric Acid. Five drams of strong acid may be put into a little flask fitted with a bent tube, 100 grains of the Sulphuret added, and a gentle heat applied. Or, Sulphuret of Iron and dilute Sulphuric Acid may be used, and the gas comes off freely without the aid of heat.



155. Hydrosulphuric Acid is chiefly employed as a test for certain metallic compounds. Take separate solutions of Arsenious Acid (common arsenic), Tartrate of Antimony and Potash (tartar emetic), and Acetate of Lead (sugar of lead), and pass the gas through them with the above apparatus. In the first solution, it will produce a pale-yellow, in the second an orange-red, and in the third a black precipitate.

156. The presence of Hydrosulphuric Acid in coal gas may be detected by holding a card coated with Carbonate of Lead over an open unlit jet, when it will speedily be

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blackened. An atmosphere contaminated with this gas may be purified with Chlorine. (See par. 169.) The equivalent number of Hydrosulphuric Acid is 17; symbol, HS.

157. Bisulphuret of Carbon is a heavy, transparent liquid, remarkable for its great and peculiar solvent powers, readily dissolving substances which no other fluid has much influence over, as sulphur, phosphorus, iodine, caoutchouc, gutta percha, gun cotton. It is also distinguished for volatility and high refractive power. It has a pungent taste and fetid odor; it is inflammable, burning with a blue flame. It is miscible in alcohol or ether, and may be separated again by adding water. Bisulphuret of Carbon was accidentally discovered by Lampadius, in 1796. It may be prepared by distilling six parts of iron pyrites with one of charcoal, in a clay-luted porcelain tube, connected with a receiver half full of water. This process requires the heat of a portable furnace, and is somewhat difficult. Specific gravity, 1.27. Equivalent number, 38; symbol, CS_2.

PHOSPHORUS.

158. Pure Phosphorus is a semi-transparent and nearly white solid, resembling wax both in color and softness. After being kept some time in solar light, it acquires a thin reddish-brown coating. Exposed to the air, it undergoes slow combustion at common temperatures, appears luminous in the dark, and emits white acid vapors. A very slight increase in heat is sufficient to kindle it in the open air.

159. Phosphorus was discovered in 1669, by Brandt, a German alchemist, who prepared it from urine; but when it was found out that bone contains Phosphate of Lime, it was substituted. The bones are ignited in an open fire, which consumes the animal matter, reduced to powder, and steeped for a day or two in strong Sulphuric Acid. Water is then added, and the whole filtered. This liquid is evaporated down to the consistence of syrup, mixed with powdered charcoal, and put into a well-luted earthen retort. A steady strong heat is required, and the Phos-

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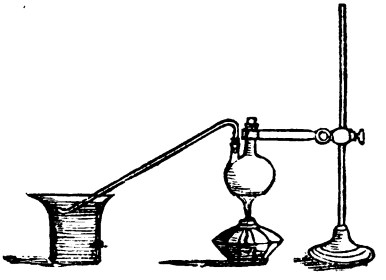
phorus sublimes over into water. The process is difficult, and not unattended with danger.

160. Aided by a moderate heat, Phosphorus is soluble in ether, alcohol, mineral naphtha, and oils. It is not soluble in water, and should be kept under water, and cut there when wanted. Great care must be taken in handling Phosphorus; it sometimes takes fire even at little more than blood-heat, and inflicts a severe burn which takes a long time to heal.

161. The name is derived from *φως*, *light*, and *φερειν*, *to carry*.

162. Phosphoric Acid, composed of Phosphorus and Oxygen, is found in bone-earth, combined with Lime. It may be prepared most conveniently by burning Phosphorus in dry atmospheric air, when it is got in the form of a snow-white anhydrous powder. This substance deliquesces rapidly when exposed to the air, and unites with three equivalents of water. This is called tribasic acid, to distinguish it from two other varieties of the same compound called monobasic and bibasic acids, which respectively unite with one and two equivalents of a base. Equivalent number, 98; symbol, $PO_5, 3HO$.

163. Phosphuretted Hydrogen is a colorless gas, remarkable for bursting into flame spontaneously on reaching the atmosphere. It has a bitter taste, nauseous smell, and cannot support combustion. Phosphuretted Hydrogen is supposed to be the gas sometimes seen in fitful combustion over graveyards and marshes, popularly named "Will o' the wisp," or, "Jack o' lantern."



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164. Half fill a small flask with a weak solution of caustic Potash, and then introduce five or six small peas of clean Phosphorus, along with a few small pieces of Potash. Apply heat with a spirit-lamp, and, as soon as gas begins to come off, dip the end of the conducting-tube into water. The bubbles of gas take fire spontaneously as they reach the surface, and, in a calm atmosphere, white rings ascend. Equivalent number, 34; symbol, PH_3.

CHLORINE.

165. Chlorine — called by the older chemists Oxymuriatic Acid — is a yellowish-green colored gas, viewed by daylight; it has an astringent, disagreeable taste, and a suffocating odor. Chlorine may be condensed into the liquid form under a pressure equal to four atmospheres, but rapidly resumes the gaseous state when the pressure is removed. One pint of pure water absorbs twice its bulk of the gas. Specific gravity, 2.47. Chlorine is found in common salt and other minerals; it is also a component part of the gastric juice.

166. Though at one time called an acid, Chlorine has no acid properties. A lighted taper burns in it for a short time with a small red flame and much smoke. Brown paper steeped in warm oil of turpentine, or a piece of dry Phosphorus, take fire spontaneously when lowered into a jar of Chlorine. So do several metals, in the state of fine powder; namely, Arsenicum, Antimony, Bismuth, Copper, Tin, and Zinc.

167. Chlorine is the great bleaching agent. Colors of great stability are entirely removed; and, if the application be continued long enough, it also destroys the fibre, making the cloth fragile and rotten. Moisture is essential to the manifestation of its bleaching power. In other terms, dry Chlorine cannot bleach a dry article; one or other must be moist.

168. Pour into one glass a purple-colored infusion of cabbage, and into another a little tincture of rhubarb. Then pass a stream of Chlorine gas through each (with the apparatus depicted on page 44), when both colors will be permanently destroyed.

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169. Guyton Morveau first applied the property which Chlorine possesses of neutralizing noxious odors. Sulphuretted Hydrogen is the most deadly gas evolved from putrefying organic matter, and Chlorine decomposes it by uniting with its Hydrogen (Hydrochloric Acid), and setting the Sulphur free, both of which bodies are innocuous. Bleaching powder may be used in fumigation. The pans should be placed on a high shelf, not on the floor. Bleaching powder gives out Chlorine slowly; but, if a weak acid be poured over it, the gas is rapidly liberated. Care must be taken, however, not to fumigate a room in this latter way, if it is occupied by a patient. Chlorine is also an excellent antiseptic.

170. Take one part Binoxide of Manganese, and pour on two parts strong Hydrochloric Acid, in a flask. A gentle heat will immediately disengage abundance of Chlorine gas, which may be collected over warm water, or by downward displacement. Chloride of Manganese and Water are the products left in the flask.

171. A solution of Chlorine may be prepared by passing the gas through cold distilled water; and as Chlorine in solution soon decomposes the water when exposed to solar light, it should be kept in a dark place.

172. The name is derived from *χλωρος, green.*

173. Chlorine forms two important compounds with Oxygen, — Chlorous and Chloric Acids, — both of which are remarkable for the feeble affinity which binds the two gases together.

174. Chlorous Acid is a deep-yellow colored gas, and so explosive that it occasionally detonates with the heat of the hand. It bleaches, and is very soluble in water. Chlorous Acid may be prepared by cautiously mixing a few drops dilute Sulphuric Acid with twelve grains powdered Chlorate of Potash, in an open capsule, so as to form a paste, transferring the mixture to a small test-tube. Heat by means of warm water not exceeding a temperature of 150°. Eq. number, 67; symbol, ClO_4.

175. Chloric Acid is chiefly interesting as entering into the composition of the Chlorates. It may be prepared by adding pure Sulphuric Acid, previously diluted, to a weak solution of Chlorate of Baryta so long as a precipitate is formed. Sulphate of Baryta falls to the

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bottom, and Chloric Acid, being set free, is dissolved in the water. It has a sour taste, and, when concentrated, a yellow color. Chloric Acid does not bleach. At a high temperature, it is resolved into its elements. Equivalent number, 75; symbol, ClO_5.

176. Hydrochloric Acid — called also Muriatic Acid, Marine Acid, and Spirit of Salt — is a colorless gas, with a strong odor, and acid taste. It emits white vapors when exposed to the air, consequent on its union with the water there suspended; it is unfit for respiration, extinguishes flame, and is not itself combustible. Dissolved in water, it causes a slight rise of temperature. Under a pressure of forty atmospheres, it may be reduced to the liquid form. One pint of cold water absorbs 480 pints of the gas. Specific gravity, 1.26.

177. The gas is most readily procured by heating the commercial acid (which is simply an impure solution), and collecting it by downward displacement.

178. To prepare the solution, first purify common salt by repeated crystallizations; then take equal parts of this purified salt, water, and Sulphuric Acid. Mix two-thirds of the water with the acid, and, on cooling, put the mixture, with the salt, into a capacious retort; the rest of the water pour into a receiver. On applying heat, Hydrochloric Acid gas is given off, and absorbed in the receiver. Sulphate of Soda is left in the retort. Specific gravity of the solution, about 1.18.

179. Tests. — Nitrate of Silver throws down a white, curdy precipitate (Chloride of Silver), distinguished from all similar precipitates by being insoluble in hot Nitric Acid and soluble in Ammonia. 2. A rod dipped in Ammonia held over the acid causes dense white fumes of the Hydrochlorate of Ammonia. Chlorates give no precipitate with Nitrate of Silver.

180. The equivalent number of Hydrochloric Acid is 36; symbol, HCl.

IODINE.

181. Iodine was discovered, in 1812, by M. Courtois, a soap-boiler, of Paris. In extracting Carbonate of Soda from the ashes of sea-weeds, he found that his metallic

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boilers soon became corroded and destroyed. He applied to a scientific chemist, who succeeded in separating a new element — Iodine.

182. Iodine is a friable, opaque solid, of a bluish-grey color, and metallic lustre. It has a bitter, acrid taste, and an odor somewhat resembling that of Chlorine. It is volatile, and, when heated, rises in dark-violet colored vapors. Iodine is about four times heavier than water. It is soluble in alcohol and ether, and still more so in a solution of Iodide of Potassium. It destroys vegetable colors, and decomposes animal matter. It stains the skin yellow; but the stain may be removed with a weak solution of caustic Potash.

183. Iodine is found in combination with Lead, Silver, &c.; also in cod-liver oil; and most abundantly in certain marine plants, from which it is prepared, after incineration. It is extensively used in medicine, and in the daguerreotype process.

184. TEST. — A cold solution of Starch forms with uncombined Iodine a deep-blue precipitate. To ensure success, both solutions should be quite cold. If the Iodine occurs in combination, no effect will be produced with the Starch; but, on adding Chlorine, the blue color appears.

185. The name is derived from *ωοδης, violet colored.*

BROMINE.

186. Bromine is a liquid at ordinary temperatures, of a dark-red color, and very disagreeable odor, remarkable for its poisonous character. A single drop placed on the beak of a small bird instantly proves fatal; and, even when considerably diluted with air, its vapor soon puts an end to life. At a temperature somewhat below zero, it freezes, and in that state is quite black and brittle. Bromine is nearly insoluble in water; its best solvent is ether. It does not redden litmus paper, but bleaches it rapidly. Specific gravity, 2.96.

187. Bromine is obtained from the supernatant liquor left after crystallizing common salt from sea-water, and it is also found in certain saline springs in Prussia and

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England, combined with Sodium or Magnesium. It was discovered by M. Balard, in 1826.

188. The name is derived from *βρωμος, a rank smell.*

FLUORINE.

189. Fluorine has never been isolated. It occurs in fluor spar, which is a Fluoride of Calcium, and can be readily enough transferred from one element to another; but, on account of the rapidity with which it attacks the vessels made use of in its preparation, all attempts at isolation have hitherto been baffled.

190. HYDROFLUORIC ACID is composed of Fluorine and Hydrogen. It may be prepared by acting on fluor spar with strong Sulphuric Acid and heat, in a leaden retort, connected with a receiver of lead, — that metal being but slowly acted upon by the acid. It is sometimes employed for etching upon glass. The plate is coated with a thin film of white wax, and the design traced with a a sharp-pointed tool, which removes the wax from the parts intended to be etched. Thus prepared, it may be exposed either to the vapor or the acid in solution.

191. The supposed equivalent number of Hydrofluoric Acid is 20; symbol, HFl.

SELENIUM.

192. Selenium was discovered, in 1818, by Berzelius, and is a rare element. It is an opaque, brittle solid, of a dark-brown color, and a metallic lustre. When heated, it gives out an odor resembling decayed horse radish, by which it is best recognized. It is insoluble in water, but soluble in Nitric Acid, forming Selenious Acid (SeO_2). Selenium bears a close resemblance to Sulphur in many of its chemical relations. Specific gravity, 4.3.

193. The name is derived from *Σεληνη, the Moon.* Selenium was at first supposed to be a metal, and Berzelius gave it this name in contradistinction to another metal named Tellurium, *the Earth.*

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BORON.

194. Boron is a greenish-brown solid, the properties of which are but imperfectly known. It is insoluble in water, and has neither taste nor smell. Specific gravity, 2.3. It may be obtained by fusing dry Boracic Acid along with Potassium in a copper test-tube.

195. Boracic Acid — the only known compound of Boron and Oxygen — exists as a natural product in the hot springs of Tuscany. It may also be procured by adding dilute Sulphuric Acid to a hot solution of purified borax. Boracic Acid is deposited in crystals as the solution cools, and should be washed with cold water. It is very fusible, and, for this reason, is used as a flux. Boiling alcohol dissolves it freely, and the solution burns with a green flame. It requires twenty-five times its weight of cold water, or three of boiling water, to dissolve it. Equivalent number, 35; symbol, BO_3.

SILICON.

196. Silicon — originally called Silicium, on the supposition that it was a metal — is a dark-brown powder, lustreless, and insoluble in acids, except a mixture of the Nitric and Hydrofluoric.

197. Silicic Acid, or Silica, is the only compound which Silicon forms with Oxygen. It is an exceedingly abundant substance, and occurs in many different shapes and colors, as quartz, flint, agate, amethyst, cornelian, rock crystal, sand. Specific gravity, 2.69.

198. Silicic Acid combines with Potash or Soda to form glass, which is a Silicate of one or other of these bases. The kind of glass depends upon the purity and quantity of the ingredients. When a large proportion of alkali is added to a small proportion of sand, a soft and easily fusible glass results. Thus, on heating one pound of sand with three of dry potash, a vitreous compound is formed, completely soluble in water, and deliquescent. If the proportions of sand and alkali be reversed, a hard glass is produced, insoluble in all acids, except Hydro-

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fluoric. Flint glass contains Lead, which renders it more ductile and heavier. Other metallic compounds are used to communicate various tints.

199. If we heat flint in an open fire, and then suddenly plunge it into cold water, it becomes brittle, and is easily reduced to a white powder. This powder is an ingredient of porcelain ware.

200. The equivalent number of Silicic Acid is 46; symbol, SiO_3.

CHAPTER III. — METALLIC ELEMENTS.

201. As a class, the metals are bound together by very few ties of similarity. There are only two properties common to the whole; namely, they are good conductors of heat and electricity.

202. Most metals are also good reflectors of light, and it is this which gives them their peculiar lustre. Some metals possess this property in a higher degree than others.

203. Metals differ considerably in their specific gravity. Potassium, for instance, is the lightest of the series, and floats upon water; whereas Platinum is so very heavy that it cannot even float upon quicksilver. They also vary in color.

204. Metals are not all alike malleable. Gold occupies the first place in this particular. It has been reduced to the 200,000th part of an inch in thickness, and is the only metal which transmits light. The malleable metals are also ductile, or capable of being drawn into wire. The reverse of malleability, ductility, and tenacity, is brittleness. Iron is the most ductile of all the metals; Antimony and Bismuth, on the other hand, rank among the most brittle. They also differ in point of hardness.

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Iron is a hard metal, Gold and Silver are much softer, and Potassium may be moulded by the mere pressure of the fingers.

205. The action of heat exhibits some remarkable differences. The first effect of heat is to expand a metal, and they differ in their rates of expansibility. When the temperature is raised sufficiently, the second effect is fusion. Mercury remains fluid at 39° below zero, while Platinum requires the enormous heat of the oxy-hydrogen blowpipe to fuse it. The third effect of heat, namely, volatilization, takes place only with some metals, such as Zinc, Arsenicum, Mercury; and these metals are purified in this way.

206. Nearly all the metals decompose water, and combine with Oxygen. Some metals unite with Chlorine more energetically than with Oxygen; and many of them are found native in combination with Sulphur.

207. There are forty-nine metallic elements; but many of these are imperfectly known, and, as yet, only chemical curiosities. We shall therefore restrict our examination to those set down in the following table, they being more abundant and useful than the others: —

NAME.	SYMB.	E. NO.	NAME.	SYMB.	E. NO.
Aluminum . . .	Al	14	Magnesium . . .	Mg	13
Antimony . . .	Sb	129	Manganese . . .	Mn	28
Arsenicum . . .	As	75	Mercury	Hg	202
Barium	Ba	68	Nickel	Ni	29
Bismuth	Bi	213	Platinum	Pt	99
Calcium	Ca	20	Potassium . . .	K	39
Chromium . . .	Cr	28	Silver	Ag	108
Cobalt	Co	29	Sodium	Na	23
Copper	Cu	31	Strontium . . .	Sr	44
Gold	Au	200	Tin	Sn	59
Iron	Fe	28	Zinc	Zn	33
Lead	Pb	104			

208. The names of the remaining twenty-six metals are — Cadmium, Cerium, Columbium, Didymium, Glucinum, Erbium, Iridium, Lantanum, Lithium, Molybdenum,

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Niobium, Norium, Osmium, Palladium, Pelopium, Rhodium, Ruthenium, Tellurium, Terbium, Titanium, Tungsten, Thorium, Uranium, Vanadium, Yttrium, Zirconium.

209. In treating this part of the subject, we will take up each metal alphabetically; adding the simple compounds it forms with Oxygen, Chlorine, Sulphur, &c., and also the more complicated bodies formed by the union of oxides of metals with acids.

210. Compounds formed with Oxygen, Chlorine, Bromine, Iodine, and Fluorine, commonly end in *ide*, as, Chloride of Silver.

211. Compounds formed either with Carbon, Sulphur, or Phosphorus, terminate in *uret*, as, Phosphuret of Calcium.

212. Acids never combine directly with metals, but always with their oxides. Compounds with acids which terminate in *ic* change into *ate*, as, Carbonate of Lead; and those with acids which terminate in *ous* change into *ite*, as, Sulphite of Potash.

ALUMINUM.

213. Aluminum is but rarely prepared. Its existence was inferred by Davy, and afterwards demonstrated by Wohler. It is got in the form of a grey powder, consisting of minute scales, which, when firmly pressed in a mortar, have metallic lustre. It is not easily fused. Specific gravity, 2.6.

214. Sesquioxide of Aluminum, or Alumina, is the chief part of common clay, and, consequently, a very abundant compound. It may be prepared by adding a solution of caustic potash to one of alum. A bulky, gelatinous precipitate is formed, which takes a long time to settle down, and, on being heated, shrinks into small bulk.

215. Pure Alumina is colorless, tasteless, glutinous, inodorous, highly insoluble in water, and requires the heat of the oxy-hydrogen blowpipe for fusion. Alumina has a strong attraction for coloring matter. Take a freshly prepared solution of cochineal, and add one of alum; then pour in a little ammonia, and a precipitate will be thrown down containing all the coloring matter.

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In dyeing and calico-printing, it is used as a mordant; the cloth being steeped in alum. It is also used in the preparation of lake pigments. Alumina is occasionally found in the crystalline form. Those beautiful gems, the ruby and sapphire, are nearly pure Alumina. Equivalent number, 52; symbol, Al_2O_3.

216. Sulphate of Alumina and Potash, or Alum, was at one time wholly obtained from Italy; and is still manufactured at Tolfa, near Rome, from alum-stone, a felspathic rock. It is also prepared, in Scotland, from alum-slate, a compound of Sulphur, Iron, and Alumina. The slate is roasted, to expedite the conversion of the Sulphur into Sulphuric Acid; then lixiviated, and the Sulphate of Alumina separated from salts of iron and other impurities by repeated crystallizations. When sufficiently pure, Carbonate of Potash is added; and the double salt thus formed, after evaporation, is poured into large tubs to crystallize.

217. Alum has a strong astringent taste; it is transparent and colorless, soluble in its own weight of boiling water and in five parts of cold water. It cannot be decomposed below a red heat. The crystals are pyramidal shaped, and contain nearly half their weight of water, all of which they lose on being heated. It is then called anhydrous or burned alum, has a frothy look, and in this form is used as medicine. Common alum is made use of in the preparation of sheepskin and writing paper. The equivalent number of anhydrous alum is 259; symbol, $Al_2O_3, 3SO_3 + KO\,SO_3$. The crystals contain 24 HO.

218. In the manufacture of alum, soda is sometimes substituted for potash. This variety is called soda-alum; the crystals contain twenty-six equivalents of water, and are efflorescent.

219. Test. — Alumina is precipitated from its acid solutions either by Carbonate of Potash or caustic Potash. When the latter is used, the precipitate may be redissolved by adding an excess of the precipitant.

ANTIMONY.

220. Antimony occurs native as a Sulphuret. This ore is called Antimony in commercial language, while

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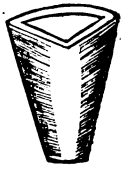
the metal itself receives the name Regulus of Antimony. It has a blueish-white color, and is distinctly crystalline in structure, presenting the appearance of thin plates laid on the top of one another, like the steps of a stair. Antimony is very brittle, and when alloyed even in small proportions with gold, silver, or lead, renders these also brittle. It fuses at a dull red heat, and possesses the remarkable property of expanding at a certain stage in cooling. Antimony is an important ingredient in type-metal, of which it forms about twenty per cent. Specific gravity, 6.7.

221. Antimony may be prepared by heating the native sulphuret with half its weight of iron filings and a little cream of tartar, in a covered Hessian crucible. Or the crucible may first be made red-hot, and then a mixture of three parts sulphuret, two cream of tartar, and one of nitre, projected into it. The reduced metal will be found at the bottom of the crucible.



222. The name is taken from *antimoines* (fatal to monks), and is connected with a story told about its discoverer, Basil Valentine. In trying its properties, he mixed a little with the food of some pigs, which, although sickened at first, throve amazingly afterwards. This emboldened Basil to repeat the experiment on a number of his lean monasterial brethren, but not with a like success, for it killed them. The ore was called Stibium by the ancients; hence the symbol, Sb.

223. TERSULPHURET OF ANTIMONY is the most abundant native ore of the metal, and that from which its other preparations are derived. It has a dark-grey color, like dull lead, and a partial metallic lustre. It may be fused in close vessels. It is soluble in boiling Hydrochloric Acid, at the same time giving off Hydrosulphuric Acid gas, and forming Terchloride of Antimony and Water. (See pars. 154, 224.) Equivalent number, 177; symbol, SbS_3.

224. TERCHLORIDE OF ANTIMONY is formed when the powdered metal is thrown into Chlorine gas; the combination is generally attended with sparks. It may also be prepared by boiling the native sulphuret in Hydro-

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chloric Acid. At ordinary temperatures, it is a soft, deliquescent solid, easily liquefied by heat, and crystallizes on cooling. Equivalent number, 234; symbol, $SbCl_3$.

225. Teroxide of Antimony may be procured by pouring the fresh Terchloride into a large quantity of water. A curdy, white precipitate falls down, which should be collected on a filter, and dried over the water-bath. To purify this precipitate, it may be boiled along with Carbonate of Potash, and washed with distilled water. The Teroxide is also formed during the combustion of Antimony in air, and, when the process is skilfully conducted, may be obtained in fine silver-like needles. Equivalent number, 153; symbol, SbO_3.

226. Tartrate of Antimony and Potash, or Tartar Emetic, is the only well-known soluble salt of Antimony. It is highly poisonous. The crystals are efflorescent, and soluble in two parts of boiling, and fourteen parts of cold water. Tartar emetic may be prepared by adding finely powdered Bitartrate of Potash (cream of tartar) and Teroxide of Antimony, in equal parts, to hot water, and continuing the heat until both are thoroughly dissolved. Recently precipitated teroxide answers best for this purpose, and the materials should be added in successive small portions. Crystals of tartar emetic are deposited on cooling. This substance is frequently administered as an emetic, and applied externally in the form of ointment as a counter-irritant. Equivalent number of the anhydrous salt, 332; symbol, $SbO_3, KO, \overline{T}$. The crystals contain 2 HO.

227. Test.—Hydrosulphuric Acid throws down an orange-red precipitate. The solution should be previously boiled along with a little Tartaric Acid.

ARSENICUM.

228. Arsenicum is found in the ores of cobalt, nickel, and iron. On roasting the ore in a reverberatory furnace, Arsenicum sublimes, and is deposited in the chimney as an oxide. This oxide is the well-known poison arsenic; and from this the metal is procured, by heating

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it with twice its weight of black flux in a covered Hessian crucible.

229. Arsenicum is crystalline in structure, brittle and volatile. It sublimes at 356°, and, in the state of vapor, has a strong smell of garlic. The pure metal is not poisonous. Specific gravity, 5.8.

230. Arsenious Acid, or White Arsenic, is commonly procured as a secondary product during the roasting of Cobalt ore. At first, it comes to hand in transparent cakes, but they gradually become opaque. It is retailed in the form of a white powder.

231. Arsenic has a slightly sweetish taste, approaching to acidity. Wet litmus paper becomes reddened by contact with the powder. It is but sparingly soluble in water. Five hundred parts of boiling water dissolve thirty-eight of arsenic, and the same quantity of cold water only dissolves one and a quarter part. It is still less soluble in milk, tea, beer, &c. Equivalent number, 99; symbol, AsO_3.

232. Tersulphuret of Arsenic, or Orpiment, is found native, and may be prepared artificially by passing a stream of Hydrosulphuric Acid gas through a solution of arsenic. It has a lemon-yellow color; it is insoluble in water, but soluble in potash, soda, or ammonia, yielding a colorless solution. Orpiment is easily fused, and, if cooled slowly, shows a crystalline structure. It is the basis of "King's yellow," and may be used as a dye for silk by dissolving recently prepared orpiment in ammonia, and dipping the cloth in this solution. While drying, the ammonia evaporates, and orpiment is deposited in the silk of a beatiful yellow color. Equivalent number, 123; symbol, AsS_3.

233. Arseniuretted Hydrogen is a highly poisonous gas, which the young student should not attempt to prepare. Gehlen, a German chemist, was accidentally killed by it. Arseniuretted Hydrogen is generated whenever nascent Hydrogen is brought in contact with a solution of arsenic, as happens in "Marsh's test." It is combustible, burning with a blue flame, but is not a supporter of combustion. It is colorless, and has a fetid odor, like garlic. Equivalent number, 78; symbol, AsH_3.

234. The only antidote for arsenic which can be relied

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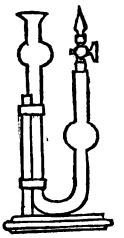
on is the hydrated Sesquioxide of Iron, prepared at the time, and given in large doses. It acts beneficially by forming insoluble Arsenite of Iron. The antidote may be prepared by pouring dilute ammonia (hartshorn) into a solution of the Persulphate of Iron.

235. Tests. — 1. Slightly acidulate the suspected solution with Acetic Acid, and transmit a slow current of Hydrosulphuric gas through it. The presence of arsenic is demonstrated by the formation of a lemon-yellow precipitate, which should be carefully dried, mixed with black flux, and heated in a German glass test-tube. A ring of metallic Arsenicum is deposited in the upper part of the tube. 2. Add ammonia, in drops, to a weak solution of Sulphate of Copper until the precipitate at first thrown down is nearly all redissolved. This preparation gives a grass-green precipitate with pure solutions of arsenic. 3. Marsh's test consists in forming Arseniuretted Hydrogen, and getting Arsenicum. The woodcut represents one form of his apparatus. A small piece of pure zinc is suspended at the bottom of the outer limb, and the suspected liquid, previously mixed with pure oil of vitriol, poured into the inner limb till it nearly reaches the stopcock. Gas is immediately disengaged, and lit at the jet, whilst a cold porcelain plate is held close to the flame. In the event of the solution containing arsenic, a film of the metal is deposited.



BARIUM.

236. This metal, which is seldom prepared, was discovered by Davy in 1808. It has a grey color, is easily fused, and probably has a high specific gravity, as it sinks rapidly when thrown into strong Sulphuric Acid. It must be preserved in mineral naphtha, or in some way cut off from the air; otherwise it is rapidly converted into Baryta. When Barium is thrown into water, a portion of the latter is decomposed, Hydrogen escapes with effervescence, and Oxygen combines with the Barium, forming Baryta, which is dissolved in the remaining water.

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237. PROTOXIDE OF BARIUM, or Baryta, may be got by heating Nitrate of Baryta in a crucible. It is a grey powder, with a caustic, alkaline taste, and has a great affinity for water. It is insoluble in alcohol. When slaked with water, great heat is evolved, and a hydrate formed which is fusible at a red heat, and retains the water even above that temperature. The solution rapidly absorbs Carbonic Acid when exposed to the atmosphere. Equivalent number, 76; symbol, BaO.

238. CHLORIDE OF BARIUM is prepared from Sulphate of Baryta by the following process: Take two parts sulphate to one of charcoal powder, and expose the mixed mass to a white heat, for an hour, in a Hessian crucible. After it has become cold, dissolve out the soluble part with boiling water, and filter. The filtered liquid is Sulphuret of Barium, and has a yellow color. While warm, add Hydrochloric Acid until it no longer yields fumes of Hydrosulphuric Acid; the process should be carried on under a chimney, or in the open air, and is assisted by a moderate heat. Concentrate this solution, and set it aside to cool, when crystals of the chloride will be deposited, in the shape of flat, four-sided tables. Chloride of Barium is readily soluble in water, but nearly insoluble in strong alcohol. The crystals contain two equivalents of water, and are valuable as a test for Sulphuric Acid. (See par. 151.) Equiv. number, 103; symbol, BaCl.

239. SULPHURET OF BARIUM is formed when Hydrosulphuric Acid gas is passed over Baryta kept at a red heat; or, as above directed, by heating sulphate with coal dust in a crucible. Sulphuret of Barium is soluble in warm water, and crystals may be obtained from a strong solution as it cools. An open solution absorbs Oxygen and Carbonic Acid from the atmosphere, and is converted into Carbonate of Baryta. Equivalent number, 84; symbol, BaS.

240. SULPHATE OF BARYTA, or Heavy Spar, is a natural production, occurring both in masses and crystals, and is the salt from which the other compounds of baryta are derived. It is commonly sold in the form of a white powder, which is about four times heavier than water, and capable of bearing an intense heat without fusion or any other change. Sulphate of Baryta is one of the

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most insoluble substances known, neither acids nor alkalies having any power to dissolve it. This is the salt which is precipitated when Chloride of Barium is added to a solution containing Sulphuric Acid or soluble sulphates. Equivalent number, 116; symbol, BaO,SO_3.

241. Nitrate of Baryta is sometimes used as a test for Sulphuric Acid, in place of the Chloride of Barium. It may be prepared in the following way: Add a solution of washing soda to one of the sulphuret until no further precipitate is thrown down. This precipitate is Carbonate of Baryta. Allow it to subside, decant off the clear solution and throw it away. Wash the precipitate thoroughly with water, and add dilute Nitric Acid in small portions, until effervescence ceases. The process should be conducted over a sandbath, and the materials constantly stirred. The crystals first procured are very acid; they should be gently heated, redissolved in distilled water, and again crystallized. Nitrate of Baryta may also be prepared from the native carbonate by the above process, of course omitting the soda. It is soluble in ten parts of cold water, or four of boiling water, insoluble in alcohol, highly poisonous, and the crystals are anhydrous. It is the chief ingredient of "green fire," burned in theatres. Equivalent number, 130; symbol, BaO,NO_5.

242. Carbonate of Baryta occurs native in the lead mines of England. The crystals are heavy, tasteless, insoluble in water, anhydrous, and very poisonous. It may also be procured by adding a solution of Carbonate of Ammonia to one of Nitrate of Baryta. In this state, it is soluble to some extent in water saturated with Carbonic Acid. Equivalent number, 98; symbol, BaO,CO_2.

243. Test. — Sulphate of Lime, in solution, or pure Sulphuric Acid, throw down a dense, white precipitate (Sulphate of Baryta), which may be recognized by its insolubility in acids and alkalies, and a high specific gravity.

244. The name is taken from *βαρυς, heavy*.

BISMUTH.

245. For a long time, Bismuth was confounded with Lead. The alchemists fancied that "base" metals were

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gradually being converted into "noble" metals, and they concluded that Bismuth was in progress of conversion from Lead to Silver.

246. Bismuth has a sort of pink color. It is more easily fused than Lead, and crystallizes in cubes. It is but an imperfect conductor of heat, and ranks next to Antimony in brittleness. Specific gravity, 9.8.

247. Terchloride of Bismuth may be prepared by boiling the nitrate in Hydrochloric Acid, or by pouring the powdered metal into a jar of Chlorine gas. It is an opaque solid, of a greyish-white color, and easily fused. Equivalent number, 318; symbol, $BiCl_3$.

248. Nitrate of Bismuth is formed when the metal is dissolved in dilute Nitric Acid. The crystals are transparent, colorless, and contain three proportions of water. Equivalent number, 291; symbol, BiO_3,NO_5.

249. Subnitrate of Bismuth, or Pearl-white, is precipitated as a beautiful white powder when the nitrate is thrown into water. It is sometimes employed as a cosmetic; but its patrons should not come near a coal fire, because most kinds of coal contain sulphur, and the Hydrosulphuric Acid gas then generated blackens the subnitrate. Equiv. number, 765; symbol, $3BiO_3,NO_5$.

250. Tests. — 1. Soluble salts of Bismuth are decomposed when thrown into a large quantity of water. 2. With Ferrocyanide of Potassium, they give a white precipitate which is insoluble in Hydrochloric Acid. 3. A stream of Hydrosulphuric Acid gas throws down a black precipitate.

CALCIUM.

251. Calcium is the metallic base of lime. It was discovered in 1807, by Davy, who procured it by decomposing chalk-paste in contact with quicksilver, by means of a powerful galvanic battery. Calcium has a pure white color, and has hitherto been prepared only in minute quantities. When put into water, the latter is decomposed; in the air, it rapidly becomes oxidized, and, when heated, burns brightly: in all three cases, lime being formed.

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252. Protoxide of Calcium, or Lime. This widely diffused and well-known compound is got from Carbonate of Lime, every variety of which yields it when heated to redness. The expulsion of the Carbonic Acid is facilitated by mixing wood with the limestone, and allowing a free current of air.

253. If left uncovered, quicklime gradually absorbs water and becomes a hydrate, or, more rapidly, by pouring on water, for which it has a strong attraction. The hydrate is sparingly soluble in water, and is more soluble in cold than in hot water. A cold solution of lime, on being heated, throws down a portion of the lime it previously held in solution. Lime is soluble in all acids. Some limestones which contain Silicate of Alumina, after being heated, yield a hydraulic lime, remarkable for speedily consolidating when mixed with water.

254. Lime is a white, brittle solid, with a caustic, acrid taste, alkaline, and very infusible. Specific gravity, 2.3. Caustic lime is used as a manure, and, in this relation, acts beneficially by decomposing organic matter and setting free the salts. It is also extensively used in the purification of coal gas. Along with sand and water, it forms common mortar. Equivalent number, 28; symbol, CaO.

255. Lime-water is prepared by adding recently slaked lime to cold water, in a stoppered bottle, shaking it occasionally during a day or two. When the lime has settled completely, draw off the clear solution. Lime-water should be carefully preserved from the air, so as to prevent absorption of Carbonic Acid. Milk of Lime consists of the hydrate mechanically suspended in water.

256. Chloride of Lime, or Bleaching Powder, is made by exposing recently slaked lime to a current of Chlorine gas. Its real composition is doubtful. Some chemists think that it principally consists of Hypochlorite of Lime; others, that it is an Oxychloride of Calcium. It is much used for bleaching and fumigation.

257. Chloride of Calcium is prepared by dissolving marble in Hydrochloric Acid, and evaporating the solution to dryness. Formed in this way, it is an amorphous, frothy looking solid, of a pale-yellow color, and glutinous feel; but, with care and painstaking, it may be crystal-

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lized. It is very deliquescent, and therefore made use of to dry gases. (See par. 57.) It is freely soluble in alcohol. Chloride of Calcium and pounded ice may be used as a freezing mixture. Equivalent number, 55; symbol, CaCl.

258. FLUORIDE OF CALCIUM, or Fluor Spar, is a natural product, extensively met in the Derbyshire lead mines, where it occurs in cubic crystals of various colors. It is insoluble in water, slightly soluble in Hydrochloric Acid, fuses at a red heat, and may be decomposed by digestion in hot Sulphuric Acid. Fluoride of Calcium is also found in fossil and recent bones, and in tooth-enamel. Equivalent number, 39; symbol, CaFl.

259. SULPHATE OF LIME exists naturally in three varieties; namely, gypsum, selenite, and alabaster. The two former each contain one proportion of water; alabaster is anhydrous. Selenite is a crystallized hydrate; gypsum is amorphous, and, after being heated in an oven at a temperature not exceeding 260°, it is called "plaster of Paris," and is used for taking stereotype moulds, casts of figures, &c. When the gypsum has been overheated, it does not "set," or solidify, after being mixed with water. Too much water has the same effect even on good plaster of Paris. Equivalent number, 68; symbol, CaO,SO_3.

260. NITRATE OF LIME may be prepared by adding dilute Nitric Acid to chalk, and evaporating the solution till it crystallizes on cooling. It forms needle-shaped groups of crystals, which are deliquescent, soluble in one-fourth of their weight of water, and in an equal weight of alcohol. Eq. number, 82; symbol, CaO,NO_5.

261. CARBONATE OF LIME is the most abundant mineral in the earth, occurring in nearly every country. Calcareous spar and Carrara marble are among its purest forms. It is insoluble in water, but soluble in the weakest acids, including even the carbonic. Carbonate of Lime is decomposed at a red heat. Chalk, shells, and limestone, are the more common varieties. Eq. number, 50; symbol, CaO,CO_2.

262. PHOSPHATE OF LIME, or Bone-earth, is the chief earthy constituent which imparts firmness to bones, and is got by burning them in an open fire. It is insoluble

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both in water and alcohol, but dissolves readily in dilute Hydrochloric Acid. Bone-earth is used by assayers in refining silver, and also in manufacturing Phosphate of Soda (tasteless salts). It is useful in removing grease spots. Eq. number, 437; symbol, $8CaO, 3PO_5$.

263. Tests. — 1. A little soda-water (which is simply a solution of Carbonic Acid) produces a milky appearance in water containing lime. If added in excess, however, the milkiness disappears, because Carbonate of Lime is soluble in an excess of Carbonic Acid. 2. Breathe through a glass tube into lime-water; the same milkiness is produced. 3. Tincture of soap gives a white precipitate when the lime is in abundance. 4. Oxalate of Ammonia is the most delicate test; a few drops give a a copious white precipitate (Oxalate of Lime).

CHROMIUM.

264. This metal was discovered by Vauquelin, in 1797. It occurs in a scarce mineral, the Dichromate of Lead, and more abundantly in an iron ore found at the Shetland Isles, and also in the State of Maryland. It is a brittle metal, of a dirty-white color, and is fused with difficulty. Specific gravity, 5.8.

265. Sesquioxide of Chromium is best prepared by heating Chromate of Mercury to redness in an earthen crucible. It is a beautiful green powder, insoluble in water, and, after ignition, nearly insoluble in acids. When fused with borax, it forms a fine green pigment, used for painting on porcelain and glass. The emerald gem owes its green color to the presence of this oxide. Eq. number, 80; symbol, Cr_2O_3.

266. Chromic Acid may be obtained nearly pure by the following process: Make a saturated solution of Bichromate of Potash. After it is cold, take two fluid ounces of the solution, and pour it into three fluid ounces of strong Sulphuric Acid in a porcelain capsule like the annexed figure, stirring well at the same time.

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Cover the capsule, and allow the whole to cool slowly. Red, prismatic crystals are deposited, which may be dried on a porous tile covered with a bell-glass.

267. These crystals are deliquescent, inodorous, and have an acid-bitter taste. When dissolved in a small quantity of water, a deep-red solution is formed; in a large quantity of water, the color is bright yellow. Chromic Acid is a powerful bleaching agent, and is used by calico printers to discharge indigo blue and other colors. With certain bases, it forms useful pigments. Equivalent number, 52; symbol, CrO_3.

268. TESTS. — 1. Caustic potash produces a green precipitate. 2. Chromic Acid is decomposed by organic matter into the sesquioxide. 3. Melted with borax, before the blowpipe, a green bead is formed.

269. The name is derived from *χρωμα, color*, owing to the beautiful colors of many of its compounds.

COBALT.

270. Cobalt occurs in nature as an arseniuret. This ore is broken in pieces, and reduced in a reverberatory furnace to an impure oxide, called "zaffre," from which the metal itself is procured by passing dry Hydrogen over it while heated to redness in a porcelain tube.

271. Cobalt is brittle, of a reddish-gray color, and is said to be attracted by the magnet. It is easily dissolved in Nitric Acid. Cobalt enters into the composition of meteoric stones, and has long been celebrated for the blue color which zaffre gives to pottery, glass, and writing paper. Cobalt ore has been found near Middletown, Connecticut. Specific gravity, 8.5.

272. CHLORIDE OF COBALT is obtained by digesting zaffre in Hydrochloric Acid. Boil the solution, filter it, then evaporate it till a thin film forms on the surface: pink crystals are deposited. The solutions of Cobalt are red, but, when dried in small quantities, appear blue; and, when much diluted, are employed as "sympathetic ink." Preparations of this metal are used in the manufacture of pictures which, by merely warming, alternately represent a summer or a winter scene. Equiv. number, 64; symbol, CoCl.

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273. Tests. — 1. Caustic potash gives a blue precipitate, which, on exposure to the atmosphere, is converted to a dirty green. 2. Hydrosulphate of Ammonia throws down a black precipitate (Sulphuret of Cobalt), insoluble in an excess of the precipitant.

274. The name is derived from Kobold, *an evil spirit*, and was conferred on it by the German miners, who supposed that it was laid in their path to deceive them while in search of more valuable ores.

COPPER.

275. Copper is a plentiful metal, and was known to the ancients. It sometimes occurs native. At the Lake Superior copper mines, it is found in large, amorphous masses; also in Australia; and, for an indefinite period, in Cornwall, where it is procured from copper pyrites, a sulphuret of the metal, mixed with clay, silica, iron, and arsenicum.

276. When this ore is employed, it is broken into small pieces and roasted, to drive off the sulphur and arsenicum. Afterwards it is smelted, which process consists in heating the roasted ore with powdered scoria: the copper fuses, and is run off into water.

277. Copper has a characteristic color, approaching to red. It is malleable and ductile, and ranks next to iron in tenacity; it is capable of taking on a high polish, and is elastic and sonorous. Copper is soluble in most acids, particularly the nitric, and partially soluble in ammonia. It is also acted upon by organic acids, forming poisonous compounds.

278. Protoxide of Copper, or Black Oxide, may be prepared by heating the nitrate to redness in a crucible. This is the base contained in all the salts of copper. It is mixed with Chlorate of Potash in preparing Oxygen, and greatly facilitates the result; but the black oxide is not itself decomposed, and may be used any number of times by dissolving out the residual chloride, and drying the black powder. It is also serviceable in organic analyses. Eq. number, 39; symbol, CuO.

279. Protochloride of Copper has an intensely green

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color, and crystallizes in needles which contain two proportions of water. It may be prepared by dissolving the protoxide in Hydrochloric Acid. The crystals are deliquescent, and soluble in alcohol. On driving off the water of crystallization by heat, a light brown powder is left, which regains its green color on adding water. Eq. number, 86; symbol, CuCl.

280. SULPHURET OF COPPER is formed when Hydrosulphuric Acid is passed through a salt of copper in solution. It is of a dark-brown or black color. Eq. number, 47; symbol, CuS.

281. SULPHATE OF COPPER, or Blue Vitriol, is an extensive article of commerce. It is obtained on the large scale by roasting the native sulphuret, and exposing it to air and moisture, which oxidizes both the constituents; the mass is then lixiviated, and the solution evaporated. The crystals are blue, soluble in four parts of cold and two of boiling water, insoluble in alcohol, have a styptic, metallic taste, and contain about thirty-six per cent of water. Heated to 450°, they lose their water of crystallization, becoming colorless and amorphous; but, on adding the same amount of water, it combines with the powder, the blue color immediately returns, and there is considerable rise of temperature. Sulphate of Copper is sometimes used by surgeons as an escharotic; in cases of poisoning, it may be given as an emetic (full dose, twelve grains), should Sulphate of Zinc not be at hand. It is also used in dyeing, and to prevent dry rot in wood. Equivalent number, 79; symbol, CuO,SO_3. The crystals contain 5 HO.

282. NITRATE OF COPPER is got by dissolving the metal in Nitric Acid. A large quantity must be operated upon in order to get fine crystals. It is a poisonous salt, deliquescent, soluble both in water and alcohol, and readily decomposed at a red heat, only the protoxide remaining. It has an acrid taste, and occasionally is applied as an escharotic. Equiv. number, 93; symbol, CuO,NO_5.

283. DICARBONATE OF COPPER, or Mineral Green, used by painters, may be prepared on a small scale by adding washing soda to a hot solution of blue vitriol. The green rust which forms on copper is also a carbonate. "Verdi-

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gris" is an acetate. Equivalent number, 100; symbol, $2CuO,CO_2$.

284. Tests. — 1. Hydrosulphuric Acid gives a black precipitate. 2. Weak ammonia, added in small quantity, throws down a greenish-blue precipitate; and, on adding a little more, it changes to a deep blue. 3. Ferrocyanide of Potassium gives a chocolate-brown precipitate, — a very delicate test. 4. A rod of zinc precipitates copper from its solutions in the metallic form. A clean, steel knife effects the same end, becoming speedily coated with metallic copper.

285. The name is taken from Cyprus, where it is said that copper was first exported from.

GOLD.

286. Unlike most of the elements described in this chapter, Gold has only been found in the metallic state, either pure, or united with other metals. Gold seems to have been the first metal mankind became acquainted with; its shining appearance, and the ease with which it could be worked into ornaments, added to the fact of its being commonly found near the surface of the earth, sufficiently account for this. Gold has been found in nearly every country of both hemispheres. It occurs abundantly in Russia, South America, California, and Australia, generally in the dried-up beds of rivers, mixed with sand, from which it is separated by repeated washings.

287. Gold is the only metal of a yellow color. In malleability it surpasses all the rest (see par. 204), and it takes on a high polish. Gold is remarkable for the steadiness with which it resists oxidation; it may be exposed for months to hot air and moisture, without being tarnished. It fuses at a bright red heat, though not so easily as either silver or copper. Gold is not soluble in any single acid; but a mixture of two parts Hydrochloric to one Nitric (aqua regia) readily dissolves the leaf. In this process, Chlorine is set free, and appears to be the active agent. When alloyed with silver, it may be separated by digestion in hot Sulphuric Acid.

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288. TERCHLORIDE OF GOLD is obtained by dissolving fragments of the metal in aqua regia. The excess of acid is expelled by evaporating this orange-colored solution till it becomes ruby-red. Terchloride of Gold is soluble in water, alcohol, and ether. Eq. number, 305; symbol, $AuCl_3$.

289. Take a strong aqueous solution of gold, and add an equal quantity of sulphuric ether; on agitating these in a tube, two fluids, of different specific gravity, result. That which floats on the top is an ethereal solution of gold, useful in gilding polished steel, silver, &c.; and, to effect this, the article requires only to be dipped in the solution, and afterwards washed in water.

290. TESTS. — Sulphate of Iron throws down a brown powder, which is metallic gold in a very minute state of division. 2. Protochloride of Tin yields an obscure purple precipitate (purple of Cassius).

291. Gold was called Aurum by the ancients, hence its symbol Au.

IRON.

292. This is the most useful of all the metals. It exists in upwards of fifty different minerals, and in the juices of plants and blood of animals. Iron is principally obtained from three minerals; namely, ironstone, loadstone, and red oxide. Loadstone is used in Sweden, red oxide in England, and ironstone in Scotland. The last is a carbonate, mixed with sand, clay, coal, sulphur, and limestone. "Black band" is a highly prized variety of this ore, so called from being interspersed with stripes of coal. Many varieties are found in different parts of the United States. Loadstone occurs among primitive rocks in the highlands of New York, and among transition rocks in New Jersey. Extensive iron mines are worked in Pennsylvania, Western New York, and Maryland.

293. When procured from ironstone, the ore is roasted. Layers of coal and ore are placed alternately in heaps from three to fifteen feet high, and set fire to. The calcination, which lasts for a week or longer, drives off sulphur and Carbonic Acid, and a brown oxide remains. Smelting is the next process: it is carried on in a conical

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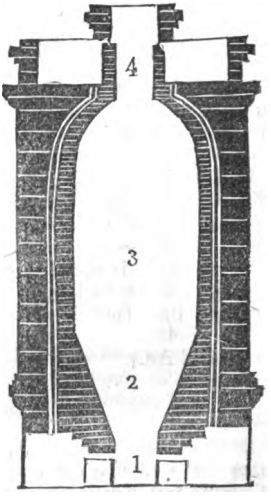
blast-furnace of great size and strength, built of fire-clay bricks, and in shape like the accompanying figure. It consists essentially of four parts — the crucible (1), boshes (2), body (3), and chimney (4). The materials are roasted ore, coal, and limestone; and are thrown in at doors in the chimney. The boshes are the hottest part. Through this the reduced metal descends into the crucible, and is there preserved from oxidation by the slag, or earthy refuse, that collects upon its surface. The use of the coal is to deprive the roasted ore of its Oxygen, and that of the lime is to assist in forming an easily fused slag. Opening near the upper border of the crucible are two holes, called "tuyères," through which pipes conveying hot air open into the furnace. Air heated to 612° (a temperature sufficiently high to melt lead), by passing through a series of red-hot tubes, is forced into the furnace by a steam-engine. Cold air was formerly used; but the hot blast possesses three marked advantages: first, coal may be used with it, whereas coke was previously needed; second, a smaller quantity of lime is required; third, a greater quantity of iron can be procured in the same period of time. Since the invention of the hot blast, an additional improvement has been made, which consists in keeping the tuyères cool with a spiral jet of water around the nozzle.



294. The metal is run off, at stated intervals, into a large mould of sand, called "the sow," from which branch off smaller moulds on each side, called "pigs," and, in that form, is sold as pig or CAST IRON. Chemically, it is a carburet, of which there are always several qualities

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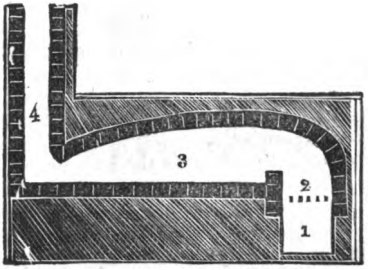
in the market, differing in tenacity, and also in the capacity for taking on a polish.

295. MALLEABLE IRON is nearly pure, seldom containing above 0.5 per cent of carbon. It is made from pig iron by two successive operations — refining and puddling. Refining consists in fusing the pig iron with coke, in which state it is kept for eight or ten hours. Puddling is performed in a reverberatory furnace, like the subjoined figure,* where the flame plays over the surface of the



metal. It is kept constantly stirred, and finally becomes of a stiff, glutinous consistence. The hot mass is removed in pieces by the puddler, and beaten by a tilting-hammer, which approximates its particles. When two pieces of iron are brought to a white heat, they can be welded, a property possessed by no other metal save platinum, and due to the fibrous arrangement of its particles. Specific gravity, 7.7.

296. STEEL is an artificial compound of pure iron and carbon. Malleable iron is heated along with layers of charcoal powder, for ten or twelve days, in an oven contrived for the purpose, from which it comes out in a blistered state, hard, and capable of taking on a fine edge.

297. It has been truly said, that if we were deprived of iron, we would be reduced to a state of barbarism.

* Represented in section: 1, the ash-pit; 2, the fire-place; 3, the body of the furnace, where the material to be operated on is placed, and over which the flame and gases play, before escaping by the chimney, 4.

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Its use in making edge-tools, implements of husbandry, machines, &c., must be familiar to every one. It forms the tools with which all implements are made, the plough that turns up the soil, the scythe that cuts down our harvests, the pickaxe that turns up gold from its earthy matrix, and, above all machines, the printing-press. It is the essential part of railroads, the electric telegraph, and the mariner's compass. It constitutes the principal part of the steam-engine, and now also the ships themselves in which so many of these engines work genii wonders. Iron is an element in common writing ink, and it has even supplanted its ancient companion — the grey goose quill; we have pens of steel, which, in our day, present a more formidable front than bayonets did of yore. In fine, we live in an age of iron, literally as well as metaphorically; for houses are built of it, and answer the purpose well.

298. Protoxide of Iron is the base found in the common salts of iron; but, on account of the rapidity with which it absorbs Oxygen from the atmosphere, it has never yet been got in a pure form. Equiv. number, 36; symbol, FeO.

299. Sesquioxide of Iron — sometimes styled Peroxide, Red Oxide — occurs naturally, and is known to mineralogists as red hæmatite. This ore, which is found in New York, Vermont, England, Saxony, France, &c., when ground to a fine powder, is used for polishing silver, and as a pigment. Common iron rust is a hydrate of this oxide, similar in composition to the antidote for arsenic, only containing less water. The hydrated sesquioxide is best prepared by adding weak ammonia to a solution of the Sesquichloride of Iron. Recently precipitated, it is readily soluble in Hydrochloric Acid; but, after being strongly heated, it is nearly insoluble. It is not attracted by the magnet. Eq. number, 80; symbol, Fe_2O_3. Ochre is a native oxide of iron, mixed with clay, sand, and lime, soft in consistence, and of a yellow color. It is used as a coarse paint.

300. Black or Magnetic Oxide of Iron seems to be a compound of the two preceding oxides. It occurs as a native product in Sweden, and is found at the foot of every blacksmith's anvil, being formed in scales when

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iron is highly heated, and beaten in the air. It is also formed when iron wire is burned in Oxygen.

301. SESQUICHLORIDE OF IRON, or Perchloride, may be prepared by dissolving iron in aqua regia, or Sesquioxide of Iron in Hydrochloric Acid. The crystals are red, volatile, deliquescent, very soluble in water, and also soluble in alcohol and ether. Eq. number, 161; symbol, Fe_2Cl_3.

302. PROTOSULPHURET OF IRON is most easily procured by bringing a bar of iron to a white heat, and pressing against it a roll of sulphur; or three parts of iron filings mixed with two of sulphur may be projected into a red-hot Hessian crucible, and covered up. It is brittle, and of a dark-brown color. It is often taken to prepare Hydrosulphuric Acid gas. Equiv. number, 44; symbol, FeS.

303. BISULPHURET OF IRON, or Iron Pyrites, occurs in two well-marked native varieties; one, of a yellow color, metallic lustre, and great hardness, which crystallizes in cubes, and is not affected by the atmosphere, may frequently be seen imbedded in roofing-slates; the other is met in beds of clay, in the shape of rounded nodules with a radiated structure internally, and crumbles down when exposed to the atmosphere, from oxidation, forming green vitriol. Eq. number, 60; symbol, FeS_2. Some kinds of pyrites are magnetic; and many varieties are found in the primitive and secondary rocks all over the United States.

304. SULPHATE OF IRON — called also Green Vitriol, or Copperas — is prepared by dissolving iron in dilute Sulphuric Acid, during which Hydrogen is evolved. Filter the solution, and set it aside to crystallize. The crystals have a bluish-green color, styptic, inky taste, and require two parts of cold water for solution; they are insoluble in alcohol. Green vitriol is employed in the manufacture of Nordhausen acid, black writing ink, and, occasionally, as an astringent in medicine. The commercial article is mostly procured from nodulated iron pyrites. Equivalent number, 76; symbol, FeO,SO_3. The crystals contain 6HO.

305. NITRATE OF IRON can with difficulty be crystallized. It is got by dissolving iron in Nitric Acid diluted

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with eight times its weight of water. The crystals are green, and very deliquescent. Eq. number, 90; symbol, FeO,NO_5.

306. Carbonate of Iron is made by precipitating a solution of green vitriol with a solution of baking soda. Sulphate of Soda remains in the liquid; and Carbonate of Iron, of a dusky-green color, is thrown down. It soon parts with Carbonic Acid, and becomes further oxidized. Carbonate of Iron is extensively used in medicine as a tonic; and, if pounded along with equal parts of white sugar, it is partially preserved from oxidation. Or, what is better, it may be prepared from solutions of green vitriol and soda in syrup. Equiv. number, 58; symbol, FeO,CO_2.

307. Tests. — 1. Ferrocyanide of Potassium gives a blue precipitate (Prussian blue). 2. Nut galls yield a black precipitate (ink). 3. Sulphocyanide of Potassium strikes a blood-red color with solutions of the persalts. In testing for iron, it is advisable to boil the solution with a drop or two of Nitric Acid.

308. The symbol (Fe) is taken from the Latin name, Ferrum.

LEAD.

309. Lead has been known since the remotest antiquity. It is always extracted from galena, a native sulphuret, either in a reverberatory furnace, or in the open air along with billets of wood, which are set on fire, and drive off the sulphur.

310. Lead has a bluish-grey color, and, when recently cut, a strong metallic lustre, which it soon loses again. Lead is not soluble to any considerable extent in cold Hydrochloric or Sulphuric Acids; but it is rapidly dissolved by Nitric Acid. It is both malleable and ductile, particularly the former; but it is inferior to all the ductile metals in tenacity, and it is not elastic. It melts at 612°. Specific gravity, 11.

311. Protoxide of Lead, or Massicot, is prepared for use in the arts by collecting the film which forms on the surface of molten lead, and exposing it to heat, while a current of air plays over the surface, until it becomes of

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a uniform yellow color. In the fused state, it is called "litharge." This oxide is the base of the salts of lead. It is extensively used in the manufacture of flint glass, which it renders more fusible. Equivalent number, 112; symbol, PbO.

312. RED LEAD, or Minium, does not seem to be a definite compound. It is manufactured by exposing massicot in shallow pans to a temperature of about 600°, taking care not to melt it, while a stream of air plays over the surface, and the powder is frequently stirred. A portion is further oxidized, and, after a considerable length of time, becomes of a bright-red color. Minium is much used as a coarse paint. A similar red oxide of lead is met with native in Germany and England.

313. Scoop out a small cavity in a piece of charcoal, and fill it with minium. Then direct on it the flame of the spirit-lamp with a blowpipe, and a globule of metallic lead will be deposited. Instead of minium, crystals of Acetate of Lead may be used, with the same result.

314. SULPHURET OF LEAD, or Galena, ranks next to the ores of iron in respect to extensive diffusion. It much resembles the metal in color, lustre, and high specific gravity. Galena is often associated with small quantities of silver. The lead mines of Derbyshire, England, and those of Louisiana, have long been worked, and are probably the most extensive in the world. Sulphuret of Lead may be prepared artificially by passing Hydrosulphuric Acid gas through a solution of the acetate. Eq. number, 120; symbol, PbS.

315. IODIDE OF LEAD is formed by boiling Acetate of Lead along with Iodide of Potassium in water. Iodide of Lead is soluble in boiling water, and may be procured in brilliant scales of a golden color and lustre by filtering the hot solution into a tall glass jar containing cold water. Eq. number, 230; symbol, PbI.

316. SULPHATE OF LEAD is thrown down as a dense, white precipitate on adding weak Sulphuric Acid to any solution containing lead. It is a heavy, insoluble powder, of which even the strongest acids and alkalies dissolve only a very minute portion. Eq. number, 152; symbol, PbO,SO_3.

317. NITRATE OF LEAD may be prepared by digesting

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scraps of lead in dilute Nitric Acid, aiding the action with moderate heat. It crystallizes in eight-sided, opaque crystals, which are soluble in seven parts of boiling water. Nitrate of Lead has a sweetish, acid taste, and is highly poisonous. It is used by calico printers, and, in the laboratory, to prepare Nitrous Acid gas. Eq. number, 166; symbol, PbO,NO_5.

318. Carbonate of Lead, or White Lead, is extensively manufactured by hanging up thin sheets of the metal where they can be acted on by the vapor of vinegar, and also by passing a slow current of Carbonic Acid gas through a solution of the trisacetate. On the small scale, it may be prepared by adding Carbonate of Soda to Acetate of Lead in solution. It is insoluble in water, but, nevertheless, is very poisonous. White lead forms the body of nearly all our colors; and, from coming so much in contact with it, house-painters are subject to "lead colic" and palsy. Eq. number, 134; symbol, PbO,CO_2.

319. Chromate of Lead, or Chrome Yellow, is best prepared by making a mixed saturated solution of the nitrate and acetate in equal parts, and adding a hot solution of Bichromate of Potash. It has a brilliant yellow color, and is used as a fine pigment, also in dyeing and calico printing. It is soluble in Nitric Acid. Equivalent number, 164; symbol, PbO,CrO_3.

320. Acetate of Lead, or Sugar of Lead, is extensively manufactured by dissolving litharge in strong vinegar, or by partially immersing thin plates of lead in vinegar, and exposing them to moist air. It crystallizes in needle-shaped crystals, which have a sweet, astringent taste, and are poisonous. It is soluble in two parts of cold water, and in eight parts of alcohol. Acetate of Lead is used externally as an astringent, sedative lotion, and sometimes internally, in doses of from two to six grains. Combined with opium, it is said to prove beneficial in British cholera. When administered in full doses, it should be accompanied with vinegar. Eq. number, 163; symbol, $PbO,\bar{A}$. The crystals contain 3 HO.

321. Tests. — 1. Lead is separated in the metallic form from its solutions by a rod of clean zinc. 2. Hydrosulphuric Acid throws down a black precipitate. 3. Chromate of Potassa gives a yellow precipitate.

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322. Lead was called Plumbum by the ancients; hence the symbol, Pb.

MAGNESIUM.

323. This rarely prepared metal was discovered by Davy about the same time as the alkaline bases; but it was not till 1830 that Bussy prepared it in sufficient quantity to examine its properties. It has a strong metallic lustre, silver-white color, is fusible at a red-heat, and very malleable. Magnesium takes fire spontaneously in Chlorine, and also when heated in the open air.

324. PROTOXIDE OF MAGNESIUM, or Magnesia. — This well-known bulky white powder is prepared by subjecting the carbonate to a red heat. It is very sparingly soluble in water, and, like lime, is more soluble in cold than hot water. Unless preserved in well-closed bottles, it soon absorbs Carbonic Acid and moisture from the atmosphere, and is converted into a tough, caky mass. It is tasteless, inodorous, and infusible. Magnesia is given as an antacid for "heartburn," and as an antidote in cases of poisoning with mineral acids. Eq. number, 21; symbol, MgO.

325. SULPHATE OF MAGNESIA, or Epsom Salts, so called from having been first discovered in a mineral spring at Epsom. — It is prepared, for commercial purposes, from dolomite, or magnesian limestone, by adding weak oil of vitriol, filtering, and evaporating the liquid. In some localities, it is extracted from "bittern," the residual liquor of sea-water after the common salt has been separated. Sulphate of Magnesia is colorlesss, soluble in its own weight of cold water, has a nauseous, bitter taste, and well-known purgative properties. Eq. number, 61; symbol, MgO,SO_3. The crystals contain 7 HO.

326. CARBONATE OF MAGNESIA. — When a cold solution of Epsom salts is mixed with a cold solution of baking soda, minute crystals are deposited: this is the neutral carbonate. Eq. number, 43; symbol, MgO,CO_2: the crystals contain 3 HO. The medicinal carbonate is prepared from similar solutions, using warm water, and it is a mixture of the hydrate and carbonate.

327. TESTS. — 1. Concentrated solutions give a white precipitate with Oxalate of Ammonia. 2. Add a few

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drops of ammonia, then Phosphate of Soda in solution, and stir well; a white, crystalline precipitate is formed. 3. Magnesia may be distinguished from other earthy compounds by forming a soluble salt with Sulphuric Acid.

MANGANESE.

328. This metal is never found uncombined in nature, but exists plentifully in the form of binoxide, from which all its other compounds are derived. Manganese is of a light-grey color, hard, brittle, and requires the highest heat of a smith's wind furnace to fuse it. Specific gravity, 8.

329. PROTOXIDE OF MANGANESE is the base contained in the salts of that metal. It may be prepared by fusing Chloride of Manganese with two parts baking soda and one part sal ammoniac, in a crucible, dissolving out the common salt which is also formed. Protoxide of Manganese is a green powder; it attracts Oxygen from the air when heated, and unites readily with acids. Equivalent number, 36; symbol, MnO.

330. BINOXIDE OF MANGANESE, or Black Oxide, is found native all over the continent of Europe, in large masses, mixed with limestone. At Ancram, N. Y., and several other places, it is found associated with iron ore. This oxide does not combine with acids. It is employed in the preparation of Oxygen and Chlorine, and, in glass-works, to give a violet tint to the ware, &c. Eq. number, 44; symbol, MnO_2.

331. CHLORIDE OF MANGANESE may be procured by evaporating the solution left in the flask after preparing Chlorine. (See par. 170.) It has a pink color, and is very deliquescent. Eq. number, 63; symbol, MnCl.

332. CARBONATE OF MANGANESE. — As this is used in the preparation of other salts of manganese, a considerable quantity of it should be prepared. Take a solution of the chloride, and evaporate it to dryness in order to expel any excess of acid. Dissolve the residue in water, take a small portion of this, and add a solution of baking soda, which precipitates Carbonate of Manganese and Sesquioxide of Iron. Wash this precipitate well, and

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boil it with the remainder of the liquid. The Carbonate of Manganese dissolves, and precipitates all the Sesquioxide of Iron. The mixture is then filtered, its solid part thrown away, and the liquid fully precipitated with baking soda. Carbonate of Manganese is a white powder, insoluble in water. Equivalent number, 94; symbol, $2MnO,CO_2$.

333. Sulphate of Manganese may be made by dissolving the carbonate in moderately dilute Sulphuric Acid, and allowing the solution to crystallize by spontaneous evaporation. The crystals have a pale rose color, and are soluble in three parts of water. Equiv. number, 76; symbol, MnO,SO_3.

334. Tests. — 1. Hydrosulphate of Ammonia gives a characteristic flesh-colored precipitate. 2. Ferrocyanide of Potassium gives a white precipitate. 3. Caustic potassa yields a white precipitate at first, which soon changes to brown.

MERCURY, OR QUICKSILVER.

335. Mercury is principally obtained from Peru and Spain, the mines in which have long been worked. It has also been found in California. Sometimes it occurs in the metallic state, but oftener as a sulphuret. Quicksilver is extracted from this ore by heating it along with lime or iron filings.

336. Mercury is remarkable as being the only metal which is fluid at common temperatures. It becomes solid at 40° below zero, and, in this state, is malleable, and can be cut with a knife. Quicksilver is often intentionally adulterated with "fusible metal," which readily dissolves in it. Pure mercury may be exposed for any length of time to the influences of cold air and moisture without being tarnished; but, when adulterated with other metals, the latter oxidize and collect as a film upon its surface. Nitric Acid readily dissolves mercury at all temperatures, and so does Sulphuric Acid when aided by heat. It is a volatile metal, and may be purified by distillation. Specific gravity, 13.5.

337. Mercury is used in collecting soluble gases which are not corrosive, and, on the large scale, in separating

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gold and silver from other metals by "amalgamation." It is the material with which barometer and thermometer tubes are filled, and several of its compounds are extensively employed in medicine.

338. Binoxide of Mercury, or Red Precipitate, is got by dissolving the metal in Nitric Acid, evaporating the solution to dryness, and afterwards applying a heat just sufficient to drive off the acid. If the heat be too long continued, Oxygen also comes off, and only metallic mercury is left. When a large quantity is prepared at once, the binoxide is procured in crystalline, shining scales, of a bright-red color; sometimes the color is dark-red. It is insoluble in water. Eq. number, 218; symbol, HgO_2.

339. Protochloride of Mercury, or Calomel, is prepared on the large scale by sublimation. The mercury is first converted into sulphate by pouring on Sulphuric Acid, and applying heat, with constant agitation, until a dry mass remains. One equivalent of this is mixed with one equivalent of the metal, and triturated together until the metallic globules entirely disappear. Two equivalents of common salt are then added, intimately mixed, and the whole put into an iron pot provided with a capacious iron head, which is neatly luted on with paste and brown paper. A fire is kindled underneath; the materials react upon each other, and the calomel which is formed sublimes and is deposited in the iron head. It is afterwards washed with water, or purified by steam. Calomel is an amorphous, white powder, tasteless, insoluble in water, not decomposed by heat, but decomposed by alkalies, including lime-water, which forms with it the well-known "black wash." Eq. number, 237; symbol, HgCl.

340. Bichloride of Mercury, or Corrosive Sublimate, is a virulent poison, soluble in water, alcohol, and ether, transparent, colorless, distinctly crystalline, and has a hot, acrid taste. The addition of common salt increases its solubility. Bichloride of Mercury is manufactured by subliming a mixture of one equivalent sulphate with two equivalents common salt, the only difference from preparing calomel being this — the metallic mercury is left out. Corrosive sublimate is strongly antiseptic, preventing decay both in vegetable and animal matter. It is used in Kyan's patent process for preserving timber from dry

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rot. The wood is steeped in a solution of corrosive sublimate for five or six days. Objections were at one time made against the use of this salt for ship timber, on the ground that ships built of kyanized timber would be likely to exhale a pestilential vapor in warm climates. But experience has proved this fear to be unfounded; for the wood does not merely undergo a mechanical saturation; the bichloride enters into chemical union with its fibres, as is proved by the experiment, that, if a piece of seasoned kyanized wood be boiled in water, no trace of corrosive sublimate can be detected by the usual tests. Eq. number, 272; symbol, $HgCl_2$.

341. BISULPHURET OF MERCURY, or Cinnabar, is the principal native ore, and may be formed artificially by fusing together eight parts of sulphur with one of the metal, and subliming the mass. This substance is called "factitious cinnabar;" and, when ground to a fine powder, it is sold as "vermilion." Equivalent number, 234, symbol, HgS_2.

342. BINIODIDE OF MERCURY is thrown down as a yellowish-red powder, which soon changes to bright-red, when Bichloride of Mercury is added in solution to Iodide of Potassium. Care must be taken not to add too much, as the precipitate is redissolved by excess of either salt. Thus, on adding a few drops of one solution to a glassful of the other, a precipitate is formed on the surface, but disappears on agitation; and, after a precipitate has been thrown down, an excess of the precipitant also redissolves it. When the dry powder is heated in a watch-glass, it loses its brilliant red color, and turns yellow; but, if this yellow powder be smartly rubbed between two folds of paper, it resumes its original color. These changes seem owing to different groupings of the particles. Biniodide of Mercury has been used as a pigment, but is a fugitive color; it has also been recently administered as an alterative in scrofula. Eq. number, 454; symbol, HgI_2.

343. NITRATE OF MERCURY may be prepared by dissolving the metal in cold, dilute Nitric Acid. Crystals are deposited on spontaneous evaporation. Symbol, HgO,NO_5. When mercury is heated in strong Nitric Acid, the metal is further oxidized, and a compound formed containing the binoxide, which is crystallized with

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difficulty. On putting either of these salts into a large quantity of water, it is decomposed.

344. Raw white of egg is the best antidote for mercurial poisons. If it cannot be got readily, milk or iron filings may be administered with good results.

345. Tests. — 1. Heat a small quantity of the suspected powder on platinum foil. If it does not sublime, then it cannot be corrosive sublimate. 2. Put four small lots of the powder on a porcelain plate, and apply the following tests: Hydrosulphate of Ammonia, dropped on one lot, blackens it; ammonia, dropped on a second, effects no change; caustic potassa, dropped on a third, gives a yellowish-red color; and Iodide of Potassium, cautiously added to a fourth, gives a vermilion tint — in the event of its being corrosive sublimate. 3. Add a solution of baking soda to one of the bichloride, and quicksilver is deposited in globules recognizable with a lens, which, by dexterous management, may be run into one large globule. 4. Place a drop of any mercurial solution on polished gold, and touch both with the point of a penknife, when a white spot appears on the gold, owing to the formation of an amalgam.

346. This metal was called quicksilver by the alchemists, who imagined that it contained silver. The name Mercury is probably taken from "the winged messenger of the gods," a resemblance the beginner will better appreciate when he spills some.

NICKEL.

347. This metal is obtained from "speiss," an artificial Arseniuret of Nickel, formed during the preparation of zaffre from the roasted ore of cobalt; and also from "Kupfernickel," a native arseniuret. Nickel is a constant ingredient in meteoric stones.

348. According to Wöhler, Nickel may be prepared by projecting finely powdered speiss, mixed with two parts nitre and one Carbonate of Potassa, into a red-hot crucible, and then raising the temperature. On cooling, the mass is lixiviated, and the Oxide of Nickel heated along with charcoal powder, which reduces it to the me-

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tallic form. As commonly prepared, it is grey, but, when pure, it is white. It is both malleable and ductile, and nearly as difficult to fuse as iron. Nickel is attracted by the magnet. It is readily dissolved by Nitric Acid. Nearly all its salts are green, and of a much deeper green than the corresponding salts of iron. Specific gravity, 8.8.

349. PROTOXIDE OF NICKEL is prepared by heating the nitrate to redness in an open crucible. It has a dark-grey color, approaching to green. It is thrown down as a hydrate when caustic potassa in solution is added to a solution of the sulphate, in which state it has a pale-green color. Eq. number, 37; symbol, NiO.

350. SULPHATE OF NICKEL is best prepared by dissolving the protoxide in oil of vitriol. It is soluble in three times its weight of water, and forms green crystals. Eq. number, 77; symbol, NiO,SO_3. The crystals contain 6 HO.

351. NITRATE OF NICKEL may be prepared by dissolving the metal in Nitric Acid. It forms emerald green crystals, soluble in water. Eq. num. 91; symbol, NiO,NO_5. The crystals contain 6 HO.

352. TESTS. — 1. Ferrocyanide of Potassium gives a beautiful green precipitate. 2. Add a few drops of ammonia to make the solution neutral, after which a current of Hydrosulphuric Acid gas throws down a black precipitate.

353. The name was conferred on it by the German miners as a term of contempt, because they expected to get copper out of it, and were unsuccessful.

PLATINUM.

354. Platinum is always found in the metallic state, frequently alloyed with gold and silver. It is chiefly procured from South America and Siberia, where it occurs in the form of grains mixed with sand. It has a white color, like silver, but less lustrous. It is heavier than any other substance we know of, except the rare metal iridium. It is malleable, and very ductile. Dr. Wollaston succeeded in drawing it into a wire 1–18750th part of an inch in diameter, and the same philosopher states

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that it is a less perfect conductor of heat than several other metals. Platinum is soft, but exceedingly difficult of fusion; and it is the only metal, besides iron, which admits of being welded. It is insoluble in all the acids taken singly, but hot aqua regia slowly dissolves it. Platinum is not tarnished by exposure to air and moisture. Specific gravity, 21.5.

355. Spongy Platinum is the metal in a minute state of division, and may be prepared by dissolving it in aqua regia, and adding a solution of sal ammoniac; a yellow powder is thrown down, which, on being dried and heated to redness, is converted into spongy platinum. In this state, it possesses the remarkable property of setting fire to Hydrogen. (See par. 65.) This phenomenon seems owing to condensation of Oxygen from the atmosphere in its pores. Professor Faraday states that perfectly clean platinum foil effects the same result.

356. Bichloride of Platinum is the yellow compound got when we dissolve the metal in hot aqua regia. When evaporated to dryness in a porcelain capsule, it assumes a reddish-brown color, is deliquescent, and soluble both in water and alcohol. Eq. number, 169; symbol, $PtCl_2$.

357. Tests. — 1. Sal ammoniac gives a yellow precipitate, insoluble in alcohol. 2. Chloride of Potassium throws down a similar yellow precipitate.

358. The name is of Spanish origin, and means "little silver."

POTASSIUM.

359. Potassium was discovered by Davy, in 1807. He prepared it from potassa by means of a powerful galvanic battery, and thus opened a path to some of the most interesting facts in chemistry. Potassium is now prepared in large quantities by calcining crude tartar, reducing the mass to powder, and introducing it, mixed with small pieces of charcoal, into a malleable iron retort, connected with a copper receiver nearly full of mineral naphtha and surrounded with ice. The retort is raised to a white heat, and potassium passes over into the receiver.

360. At ordinary temperatures, potassium is solid, but so soft that it yields like wax to the pressure of the

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fingers. At 32°, it becomes hard and brittle, and it fuses at 150°. Its specific gravity is only 0.865. Potassium is distinguished by its great affinity for Oxygen. When cut with a knife, its metallic lustre is evident; but the fresh surface becomes rapidly coated with a film of oxide.

361. Cut a small piece under naphtha, and place it in a shallow basin of water; it takes fire instantaneously, skimming along the surface with great velocity as long as the combustion lasts. It may thus be said to set water on fire, because the water is decomposed, its Oxygen uniting with part of the potassium to form potassa, and its Hydrogen combining with another part, which, taking fire, is the source of the purple flame. When exposed to the air, potassium oxidates more slowly, though with a similar result, — the formation of potassa. For this reason, it requires to be preserved in a fluid containing no Oxygen, and pure mineral naphtha, which is a hydro-carbon, answers the purpose admirably.

362. Protoxide of Potassium, Potash, or Potassa, is commonly prepared from pearlash and caustic lime. Take one part of dry lime and slake with warm water, two parts of pearlash, and about fifteen parts of hot water.* Dissolve the pearlash in the water, and add lime in small portions at a time, boiling the whole in a clean iron pot for a few minutes after each addition. When all the lime has been added in this way, boiled, and frequently stirred, it should be allowed to settle, and the clear solution decanted, or drawn off with a glass syphon. This liquid is a solution of caustic potash, and it may be evaporated down in a similar vessel to one-third of its bulk. By continued evaporation, and fusion in a silver capsule, it is got in a solid form, and is often employed as a cautery. The white powder which subsides after boiling is Carbonate of Lime.

363. Potassa is a white solid, highly caustic and alkaline, which fuses at a red heat, and requires half its weight of water for solution. It is very deliquescent, and must therefore be kept in well-closed bottles. Potassa is soluble in alcohol. In its common solid form, it is a hydrate, containing one proportion of water, which can-

* Two quarts by measure correspond to five pounds by weight.

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not be driven off even at a red heat. Eq. number, 47; symbol, KO.

364. Chloride of Potassium is the residue left in the test-tube after preparing Oxygen gas from Chlorate of Potassa. It is colorless, soluble in three parts of cold water, insoluble in alcohol, and has a salt-bitter taste. The crystals resemble those of common salt (Chloride of Sodium) in several respects, and are used in the manufacture of alum. Chloride of Potassium is more soluble in hot than cold water. It is procured, on the large scale, from "kelp" employed in the manufacture of iodine, and also during the preparation of Chlorate of Potassa. Eq. number, 74; symbol, KCl.

365. Iodide of Potassium, or Hydriodate of Potassa, is prepared by adding iodine to a hot solution of pure potassa until the latter is neutralized, evaporating to dryness, and subjecting the mass to a red heat in a platinum crucible. To procure it in crystals, dissolve the fused mass in hot alcohol, and it crystallizes on cooling. The crystals should not deliquesce in a moderately dry atmosphere. In solution, it is the best solvent of iodine, and it is extensively used as a medicine. Eq. number, 165; symbol, KI.

366. Corrosive sublimate is a good test for Iodide of Potassium, throwing down a bright red precipitate. (See par. 342.) Iodide of Potassium is very easily decomposed; even contact with moist paper sometimes sets free the iodine.

367. Sulphate of Potassa may be prepared by adding Carbonate of Potash to the salt left in the retort after distilling Nitric Acid. The crystals are colorless, anhydrous, and have a bitter, saline taste. They are soluble in sixteen parts of cold and five of boiling water, and, on account of their extreme hardness, are used by apothecaries to assist in triturating vegetable drugs. In doses of from one to four drams, Sulphate of Potassa operates as a mild purgative. It is an ingredient of "Dover's powder." Eq. number, 87; symbol, KO,SO_3.

368. Nitrate of Potassa — also called Nitre and Saltpetre — effloresces spontaneously upon the surface of the soil in several parts of the world, more especially in the East Indies, Egypt, South America, and the celebrated

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Kentucky caverns. It is also found in Virginia and Maryland. On the continent of Europe, besides that which is procured in some places from the soil, it is formed artificially by mixing old plaster, mould from tombstones, and putrefying animal matter together, under sheds, and keeping the mass constantly moist with putrid urine. Nitrate of Lime is the principal product of these "nitre beds." After standing a sufficient length of time, they are lixiviated, and crude potash added, when the Nitric Acid changes quarters, going over to the potassa, and Carbonate of Lime is precipitated. "Sal prunell" is simply fused nitre which has been cast in moulds.

369. Purified nitre is anhydrous, and yields Oxygen on being heated. It crystallizes in colorless, needle-like crystals, which have a saline taste, and leave a sensation of coolness in the mouth. Nitre is powerfully antiseptic, and is used to cure hams, &c. It is the chief ingredient in gunpowder; and is employed by chemists as an oxidating agent, also in making up frigorific mixtures, and in preparing aquafortis. Equiv. number, 101; symbol, KO,NO_5.

370. CARBONATE OF POTASSA — commonly sold as Potash — is obtained in an impure form by burning trees and other inland plants, lixiviating the ashes, and evaporating the solution to dryness in iron pots; hence the commercial name pot-ashes. The manufacture is principally carried on in Canada, the Northern States, and Russia. A bushel (sixty pounds) of wood ashes yields about four pounds of crude potash. A cord of wood furnishes about six or seven pounds. The amount varies considerably in different kinds of wood. Birch, maple, and oak yield the most; whereas resinous trees, as cedar and pine, afford very little. After the potash has been abstracted, the ashes are said to be "leached."

371. When wanted pure, Carbonate of Potassa is prepared from cream of tartar; this is heated to redness in a porcelain crucible, dissolved in water, filtered, and finally evaporated to dryness in a platinum capsule. It is very deliquescent, soluble in less than its own weight of water, difficult to crystallize, and strongly alkaline. "Pearl-ash" is a partially purified article, which contains

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a considerable amount of water. In various states, this compound is employed in the manufacture of soap and glass, and it is used by printers as a lye to cleanse type. Eq. number, 69; symbol, KO, CO_2.

372. Bicarbonate of Potassa is used as an antacid, and an ingredient in effervescing draughts. It may be prepared by passing a stream of Carbonic Acid through a solution of the carbonate till saturated. Bicarbonate of Potassa has a mild alkaline taste, is not deliquescent, and forms transparent crystals, which are soluble in four parts of cold or one of boiling water. A moderate heat reconverts it into carbonate. Eq. number, 91; symbol, $KO, 2CO_2$. The crystals contain HO.

373. Chlorate of Potassa is manufactured by transmitting Chlorine gas through a concentrated solution of the carbonate. Chloride of Potassium is formed at the same time; but, as Chlorate of Potassa is much more insoluble, it crystallizes first, leaving nearly all the chloride in the supernatant liquor. It is anhydrous, and is decomposed at a red heat. Chlorate of Potassa is much used in the manufacture of Lucifer matches, and as a source of Oxygen gas. Equiv. number, 122; symbol, KO, ClO_5.

374. Chromate of Potassa. — To prepare this salt, the native chrome-iron ore is broken into small pieces, mixed with nitre, and heated for a long time in a reverberatory furnace. The calcined mass is afterwards lixiviated and crystallized. Chromate of Potassa has a pale yellow color, a cool, bitter taste, and is soluble in two parts of cold water, but not soluble in alcohol. Equivalent number, 99; symbol, KO, CrO_3.

375. Bichromate of Potassa is formed by adding Sulphuric or Acetic Acid to a solution of the chromate. The acid combines with a portion of the potassa, forming Sulphate (or Acetate) of Potassa; and the bichromate is deposited, after spontaneous evaporation, in tabular crystals of a blood-red color. This salt is made in enormous quantities at Glasgow, Scotland, and is much used by dyers. The crystals are anhydrous, and soluble in ten parts of water. Eq. number, 151; symbol, $KO, 2CrO_3$.

376. Antimoniate of Potassa. — Fresenius gives the following directions for its preparation: "Mix four parts

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of metallic antimony with nine parts Nitrate of Potassa; project the mixture gradually into a red-hot Hessian crucible, and continue for some time to maintain the latter in a state of ignition. Boil the fused mass subsequently with water until the soluble part is completely extracted; dry the residue, mix fifty parts of it with twenty-four parts of dry Carbonate of Potassa, introduce the mixture into a Hessian crucible, and expose the latter for thirty minutes to red heat: keep the thus-produced friable mass in a stoppered vial. For use, digest one part of the triturated mass with twenty parts of water at a gentle heat, allow the solution to cool, and filter it when quite cold." Symbol, KO, SbO_5.

377. Tests. — 1. In neutral and acid solutions of potassa-salts, Bichloride of Platinum throws down a yellow precipitate. An alcoholic solution of the bichloride should be employed, and the whole well stirred. 2. In neutral and alkaline solutions, an excess of Tartaric Acid gives a white crystalline precipitate after thorough stirring.

378. The Germans call this metal Kalium, from an Arabic root; hence its symbol K.

SILVER.

379. Silver is sometimes met with pure, but more frequently in combination with lead, and as a sulphuret. The ore commonly used in Europe is the "argentiferous sulphuret of lead." It is first roasted to dissipate the sulphur, and then exposed to a red heat in a flat furnace, with a draught of air constantly playing over its surface, which oxidizes the lead, blows it away, and leaves the silver nearly pure.

380. In South America, where alloys of silver and the sulphuret are employed, the ore is mixed with common salt, and roasted in a reverberatory furnace. This converts the silver into a chloride, which, after being ground to powder, is mixed with iron filings, mercury, and water, and agitated in barrels kept revolving by machinery. An amalgam of silver is thus formed, which is pressed through coarse cloths, and the silver procured by distilling off the mercury.

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381. Silver possesses a pure white color, and is susceptible of a high polish. It is very malleable and ductile, and is not tarnished by exposure to pure air and moisture. Sulphur and Hydrosulphuric Acid gas speedily blacken it. Silver is a soft metal, and fuses at a little above a red heat. It is soluble in boiling Sulphuric Acid, and cold Nitric Acid readily dissolves it. Specific gravity, 10.5.

382. PROTOXIDE OF SILVER, according to Dr. Gregory, is best prepared by the following process: Dissolve silver in Nitric Acid, precipitate the solution with common salt, and wash the precipitate thoroughly with hot water; then cover it to the depth of half an inch with a strong solution of caustic potassa, and boil, until the chloride is entirely converted into a heavy, black powder, which should be well washed with hot water, and is Protoxide of Silver. It is soluble in ammonia. Eq. number, 116; symbol, AgO.

383. SULPHURET OF SILVER — called Silver Glance by mineralogists — has a dark-grey or black color, and is remarkably soft and malleable. Equiv. number, 124; symbol, AgS.

384. CHLORIDE OF SILVER, or Horn Silver, occurs native, and is formed on adding Hydrochloric Acid, or any soluble chloride, to Nitrate of Silver in solution. Prepared in this way, it is a white, curdy substance, which soon blackens on exposure to sunlight, is soluble in ammonia, but insoluble in boiling aquafortis. (See par. 179.) The change of color effected in this substance by light, led the alchemists to conclude that they might turn inferior metals into gold through the same agency. Equivalent number, 143; symbol, AgCl.

385. IODIDE OF SILVER is prepared by adding Iodide of Potassium to Nitrate of Silver in solution. It has a pale-yellow color, and is insoluble in ammonia. A thin film of Iodide and Bromide of Silver is formed on the surface of the plates used in taking daguerreotype pictures. Eq. number, 234; symbol, AgI.

386. NITRATE OF SILVER, or Lunar Caustic, is got by dissolving silver in weak aquafortis, and crystallizing the solution. It is colorless, transparent, and poisonous. The crystals are soluble in alcohol, and in their own

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weight of cold water. Lunar caustic is easily fused; it is sold in little cylindrical sticks about the thickness of a quill, and is much used by surgeons as a cautery. Nitric Acid seems to be the constituent which cauterizes, and the dark stain left is probably due to the deposition of oxide. Nitrate of Silver is the essential part of most hair-dyes and indelible inks. It must be kept in covered bottles, as the sun's rays decompose it. Pure Nitrate of Silver is a delicate test for organic matter, becoming decomposed and blackened on the least contact. Equivalent number, 170; symbol, AgO,NO_5.

387. Tests. — 1. A solution of caustic potassa gives a light-brown powder, soluble in ammonia. 2. Common salt throws down a white, curdy precipitate, soluble in ammonia. The clear ammoniacal solution of this precipitate yields it up again (Chloride of Silver), on adding Nitric Acid.

388. The symbol, Ag, is taken from the Latin name for silver, Argentum.

SODIUM.

389. This metal was discovered by Davy, a few days after potassium, and by the same means. It is now prepared from Acetate of Soda by igniting that salt, mixing the residue with coarsely powdered charcoal, and subjecting the whole to a white heat in an iron bottle coated with fire-clay. The receiver contains naphtha, and the process is similar to that for potassium.

390. Sodium is very soft, nearly white, and presents a brilliant metallic surface when cut. It does not generally take fire when thrown upon cold water; but, if the water be hot, and the metal confined to one spot, it takes fire and burns with a yellow flame. Specific gravity, 0.972.

391. Protoxide of Sodium, or Soda, may be prepared in the same way as potassa (see par. 362), washing soda being used instead of pearlash. It is a hydrate, containing one equivalent of water, which cannot be driven off by heat. Soda is strongly alkaline, caustic, soluble both in water and alcohol, and easily fused. Anhydrous soda is formed when sodium is burned in Oxygen. Equivalent number, 31; symbol, NaO.

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392. Chloride of Sodium — better known as Common Salt — exists abundantly in nature. It is found in most plants, and in every fertile soil; but there are three sources from which it is principally procured, — strata in the earth, brine springs, and sea-water. The salt mines of Spain are examples of the first kind, and their produce is called "rock salt." New York, Kentucky, and several other States, contain numerous valuable "salt licks," or brine springs. In tropical countries, the inhabitants of bays draw off sea-water into shallow reservoirs, where the heat of the sun evaporates it, and leaves large crystals, called "bay salt," used in curing provisions. A superior article is manufactured at Cape Cod, and elsewhere along the coast, by the spontaneous evaporation of sea-water in shallow tubs.

393. When wanted perfectly pure, it is prepared by dissolving Carbonate of Soda in weak Hydrochloric Acid; Carbonic Acid gas goes off with effervescence, water is formed from the Hydrogen of the acid and the Oxygen of the soda, and, after spontaneous evaporation, Chloride of Sodium is deposited in cubical crystals. It is also produced when metallic Sodium is burned in Chlorine gas.

394. The taste, whiteness, and universal use of common salt as a condiment are well known. It is highly antiseptic, which property is attributed by some chemists to its power of absorbing moisture; but it is more probably owing to chemical combination with the proximate principles of the tissues preserved. Chloride of Sodium allows more radiant heat to pass through it than any other substance. It is anhydrous; crystallizes in cubes, and hollow, four-sided pyramids; is soluble in about three parts of cold water, and not more soluble in hot water, and insoluble in alcohol. Good salt should not deliquesce in a moderately dry atmosphere, so that, when this takes place, it is a sign of impurity; Chloride of Potassium is often present. Common salt is used in the manufacture of bleaching powder, Carbonate of Soda, and Hydrochloric Acid. Eq. number, 58; symbol, NaCl.

395. Iodide of Sodium may be prepared in the same way as Iodide of Potassium, substituting caustic soda for potassa. It is contained in the residual liquor of kelp, and is the compound from which iodine is obtained. It

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is deliquescent, and soluble in alcohol. Equiv. number, 149; symbol, NaI.

396. SULPHATE OF SODA, or Glauber's Salt, occurs in sea-water, mineral springs, plants, and urine. It is the solid residue in the retort after preparing Hydrochloric Acid. (See par. 178.) This salt has a cooling, bitter taste, is soluble in twice its weight of cold water, and operates as a drastic purgative. The crystals contain ten proportions of water; but they rapidly effloresce and crumble down in a moderately dry atmosphere. Equivalent number, 71; symbol, NaO,SO_3.

397. NITRATE OF SODA. — This salt is found in some parts of India, and more abundantly at Atacama, Peru. The soil is simply lixiviated, and the solution evaporated to dryness; so that the crude commercial article is very impure, besides being frequently further adulterated when sold as a manure. Nitrate of Soda is deliquescent, and, on this account, cannot be used in the manufacture of gunpowder: it is soluble in two parts of cold water. It is largely used in making aquafortis and oil of vitriol. Eq. number, 85; symbol, NaO,NO_5.

398. CARBONATE OF SODA, or Washing Soda, was at one time wholly obtained from kelp and barilla, names given to the ashes of various marine plants. It is now manufactured from common salt at a vastly cheaper rate. There are three distinct processes. First, the conversion of common salt into Sulphate of Soda, or "salt-cake," by the agency of Sulphuric Acid and heat. Second, the salt-cake is mixed with limestone and coal-dust, and projected into a reverberatory furnace, where it remains in a fused state until converted into "black-ash," when it is raked out and allowed to cool. Third, the digestion of this black-ash in water, which dissolves out an impure carbonate; the solution is evaporated to dryness, mixed with sawdust, and returned to the furnace, where it is completely carbonated. In this state, most of it is sold as "soda-ash." Crystals may be obtained by dissolving soda-ash in water, evaporating slightly, and allowing the solution to cool.

399. Carbonate of Soda is colorless, strongly alkaline, and soluble in twice its weight of cold water. The crystals contain ten equivalents of water, and are very efflo-

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rescent, eventually crumbling into powder when exposed to dry air. Equivalent number, 53; symbol, NaO,CO_2.

400. Bicarbonate of Soda is commonly prepared by passing a stream of Carbonic Acid gas through a solution of the carbonate. It is sometimes used in dyspepsia. It has a mild alkaline taste, and is got in the form of a white powder, not easily crystallized, which requires twelve parts of cold water for solution. "Baking soda" is a mixture of the carbonate and bicarbonate. Equivalent number, 75; symbol, NaO,CO_2.

401. Phosphate of Soda — commonly called Tasteless Salts — is prepared from bones, the first stages being the same as those for making phosphorus. The Superphosphate of Lime is saturated with Carbonate of Soda, and the acids change places, thus forming Carbonate of Lime and Phosphate of Soda. Tasteless salts need four parts of cold water for solution; they operate as a gentle purgative, and may be given to children in soup without belying their popular name; dose, three to six drams. The crystals are efflorescent, and contain twenty-four equivalents of crystallization-water. Eq. number, 142; symbol, $2NaO+HO,PO_5$.

402. Biborate of Soda, or Borax. — This well-known salt occurs naturally in some of the lakes of Thibet and Persia. It is imported from the East Indies, in a crude state, under the name of "tincal." Much borax is now manufactured by saturating soda with the Boracic Acid got from Tuscany. Biborate of Soda is efflorescent, soluble in twenty parts of cold water, but not soluble in alcohol. It is used as a flux, and by tinsmiths in soldering. Equivalent number, 101; symbol, $NaO,2BO_3$. The crystals contain 10 HO.

403. Tests. — There are no well-defined tests for Soda, if we except Antimoniate of Potassa, which produces in neutral or alkaline solutions a white, crystalline precipitate. It is necessary, before applying this test, to make sure that there is no other base present in the solution save potassa and soda. The salts of soda communicate a yellow color to the blowpipe flame.

404. Carbonate of Soda was originally procured from mineral lakes in Egypt and Hungary under the name of Natron; hence the symbol, Na.

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STRONTIUM.

405. This metal was also discovered by Davy, in 1807. It is but imperfectly known; it resembles Barium in appearance and high specific gravity, and oxidizes rapidly on exposure to the atmosphere.

406. PROTOXIDE OF STRONTIUM, or Strontia, is strongly caustic, soluble in twice its weight of boiling water, and insoluble in alcohol. It may be prepared by heating the nitrate to redness in a crucible. Strontia, like caustic lime, rapidly combines with water, forming a white solid hydrate, which is fusible at a red heat. An open solution attracts Carbonic Acid from the air, and is speedily converted into Carbonate of Strontia. The salts of strontia are not poisonous. Eq. number, 52; symbol, SrO.

407. NITRATE OF STRONTIA may be prepared from the native carbonate by reducing it to powder, and digestion in Nitric Acid. It imparts a blood-red color to flame, and is principally used in making fireworks, and "red fire" for theatres. It is nearly insoluble in alcohol. Eq. number, 106; symbol, SrO,NO_5. Another form contains thirty per cent. water of crystallization.

408. CARBONATE OF STRONTIA is the native mineral, "strontianite." It is insoluble in water, but soluble to a small extent in a solution of Carbonic Acid. Equivalent number, 74; symbol, SrO,CO_2.

409. TEST. — The carmine-red color which strontia and its salts communicate to flame.

410. It was first procured from the native mineral found at Strontian, Scotland; hence the name.

TIN.

411. This well-known metal is obtained from tinstone, an impure oxide of tin, which has been found only in the more ancient primary rocks. It is principally procured from Cornwall, which has been famed for its tin mines for centuries. Tin is also brought from Saxony, Bohemia, the East Indies, and South America. The ore is found in veins, and also in the form of grains amongst alluvial depositions. The latter variety is called "stream tin,"

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and contains the purest oxide. Tinstone is first pounded and washed to separate earthy particles, then roasted in a reverberatory furnace, and finally heally heated along with lime and coal dust till the metal is reduced. Stream tin is reduced by heating it along with charcoal in a blast furnace.

412. When cautiously heated, tin is very malleable, and is beaten out into leaves, called tinfoil, which are so thin, that one thousand of them make but an inch in thickness. It is not so ductile, however, as many other metals, and it emits a peculiar creaking noise when bent. Tin is a soft metal, more fusible than lead, a good reflector of light, and has a yellowish-white color. It does not tarnish readily when exposed to air and moisture; at a white heat, it enters into vivid combustion, burning with a dazzling light, and is converted into the binoxide. Tin is much used to coat the inside of iron and copper cooking utensils. Specific gravity, 7.2.

413. Protoxide of Tin is formed when tin is kept fused for some time in an open vessel; also, when Carbonate of Potassa is added to Protochloride of Tin, the protoxide is precipitated as a hydrate. It is the base of all the acid salts of tin, but is not stable. Eq. number, 67; symbol, SnO.

414. Binoxide of Tin, or Stannic Acid, is made by digesting tin in moderately strong Nitric Acid. Thus prepared, it is a white hydrate, insoluble in acids; but it readily unites with potassa, soda, or ammonia, forming compound called "stannates," which are soluble in water. By heating the hydrate to redness, its water is expelled, and it assumes a pale-yellow color. This substance is an ingredient in white enamel for clock faces. Eq. number, 75; symbol, SnO_2.

415. Bisulphuret of Tin, or Mosaic Gold, is prepared by making an amalgam of twelve parts tin with six of mercury, and heating it in a Florence flask along with seven parts pure sulphur and six parts sal ammoniac in powder. It has a golden-yellow color, and is soluble both in aqua regia and caustic potassa. It constitutes the "bronze" of painters, lithographers, and type printers. Eq. number, 91; symbol, SnS_2.

416. Chlorides of Tin. — The protochloride is got by

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digesting an excess of tin in warm Hydrochloric Acid. Eq. number, 94; symbol, SnCl. The bichloride is best prepared by heating the protochloride along with a little Nitric Acid; it is a fuming, colorless liquid. Equivalent number, 129; symbol, $SnCl_2$. Chlorides of Tin are much employed by dyers and calico printers.

417. TESTS. — 1. Terchloride of Gold produces a purple precipitate (or it may be only a purplish coloration), which is insoluble in Hydrochloric Acid. 2. Mixed with equal parts of dry Carbonate of Soda and Cyanide of Potassium, and exposed on charcoal to the inner flame of the blowpipe, salts of tin are reduced to the metallic state; and the globule thus formed may be recognized by its color and great malleability.

418. The symbol, Sn, is taken from the ancient name, Stannum.

ZINC.

419. Zinc — also called Spelter in commerce — is found abundantly in two minerals, zinc-blende and calamine. The former is a sulphuret, and the latter a carbonate. The crude ore is first roasted to drive off volatile impurities, and the subsequent process is a good example of what may be called "downward distillation." Roasted ore, lime, and charcoal powder are introduced into a crucible, which is afterwards covered at the top, and luted with sand and clay; while an iron tube, open at both ends, passes through the bottom of the crucible. The zinc, in vapor, passes down this tube, and is condensed in a vessel of water below. The first portions which come over are very impure, and, when set fire to, burn with a "brown blaze;" its approach to purity is indicated by a "blue blaze," and then they begin to collect it.

420. Zinc has a bluish-white color. It is a hard, volatile metal, remarkable for being britttle both at low and high temperatures. At 320°, it is highly malleable, and may be rolled into thin sheets; but, at 600°, it is very brittle: at 773°, it fuses, and volatilizes at a white heat. When exposed to moist air, zinc undergoes little change; a film forms on its surface, but, as this is as

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expansible as the metal itself, it does not peel off in scales like iron rust. Zinc has the power of separating a great many metals from their solutions, but is not itself acted upon in this way by any other metal. It is soluble in all mineral acids, and also the acetic, so that zinc utensils should never be employed in cooking acid food. Specific gravity, 7.

421. PROTOXIDE OF ZINC may be prepared in two ways, the dry and the humid. The first method is employed when it is wanted as a pigment, and consists in fusing zinc in the open air, when it takes fire, and rises in fine flakes like snow; these are sometimes called "flowers of zinc," or "philosopher's wool." The second process consists in adding ammonia to a warm solution of the sulphate, when Protoxide of Zinc is thrown down as a bulky white powder, which is soluble in an excess of ammonia. When heated, it turns yellow. Protoxide of Zinc is soluble in acids, but not soluble in water, and is used in medicine. Eq. number, 41; symbol, ZnO.

422. SULPHURET OF ZINC, or Zinc Blende, is one of the native ores. A hydrated sulphuret may be formed by adding Hydrosulphate of Ammonia to a solution of white vitriol. It is a white powder, and the water may be driven off by heat. Eq. number, 49; symbol, ZnS.

423. CHLORIDE OF ZINC is formed, with evolution of light and heat, when zinc filings are poured into a jar of Chlorine gas; or by dissolving zinc in Hydrochloric Acid, and evaporating the solution to dryness. It is fusible at the temperature of boiling water, deliquesces in the air, and, on account of its extreme softness, has been called "butter of zinc." It is occasionally used in surgery as an escharotic. Eq. number, 68; symbol, ZnCl.

424. SULPHATE OF ZINC, or White Vitriol, is the saline residue left in the gas-bottle after preparing Hydrogen gas, when zinc is the metal used. (See pars. 59—61.) On the large scale, it is prepared by roasting zinc blende in an open furnace, when both its elements absorb Oxygen. The crystals are colorless, have a styptic taste, redden vegetable blues, are soluble in three parts of cold water, and effloresce in dry air. White vitriol is given medicinally as a prompt emetic. Equivalent number, 81; symbol, ZnO,SO_3.

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425. CARBONATE OF ZINC, or Calamine, is the preferable native ore. It is worked in England, France, and New Jersey, and the purer portions sold as a white pigment. It may also be procured by adding Carbonate of Potassa to white vitriol in solution. Eq. number, 63; symbol, ZnO, CO_2.

426. TESTS. — 1. Ammonia produces a white precipitate, soluble in an excess of the precipitant. 2. Hydrosulphuric Acid gives a white precipitate with neutral solutions of zinc, but none if the solution be acid; to ensure neutrality, therefore, previous to applying this test, add a few drops of ammonia.

ORDER OF FUSIBILITY.

427. As already mentioned, the temperature at which metals enter into fusion is very different. For the sake of comparison, a few are arranged in the following table according to their order of fusibility; beginning with the most fusible, and ending with the least so. The table also gives their respective highest specific gravity.

FUSIBLE BELOW A RED HEAT.	TEMPERATURE.	SPECIFIC GRAVITY.	INFUSIBLE BELOW A RED HEAT.	TEMPERATURE.	SPECIFIC GRAVITY.
Mercury .	—39°	13.5	Silver . .	1873°	10.5
Potassium	150	0.865	Copper . .	1996	8.8
Sodium . .	200	0.972	Gold . . .	2016	19.3
Tin	442	7.2	Iron, cast .	2786	7.0
Bismuth .	497	9.8	Manganese		8.0
Lead . . .	612	11.0	Cobalt . .		8.5
Zinc . . .	773	7.0	Nickel . .		8.8
Antimony	810	6.7	Platinum .		21.5

Manganese, cobalt, and nickel are with difficulty fused at the highest temperature of a smith's wind furnace; malleable iron with still more difficulty; and platinum requires the enormous heat of the oxy-hydrogen blowpipe to fuse it.

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CHAPTER IV.— ALLOYS AND AMALGAMS.

428. The word *alloy* signifies a metallic body composed of two or more metals intimately blended by fusion. It is also sometimes applied to a mere surface union of two metals. When mercury unites with any other metal, the resulting compound is called an *amalgam*. Thus, an amalgam of silver means the union of silver with metallic mercury.

429. An alloy of tin, copper, bismuth, and antimony constitutes "Britannia metal."

430. Common pewter is an alloy of lead and tin, with a small portion of antimony.

431. Seventy-three parts of lead, twenty of antimony, and seven of block tin, form the alloy of which printing types are made. Some type-founders add a fractional part of copper. The use of the antimony is to give hardness, and a sharp, distinct face to the type, the latter being effected by its expansion in the mould.

432. Bismuth is remarkable for the high degree of fusibility which it communicates to other metals. An alloy composed of eight parts bismuth, five lead, and three tin, is fusible below the boiling point of water, and is called the "fusible metal." Practical jokers make of it tea-spoons, which create amusement by melting in the cup when employed to stir hot tea.

433. Bronze is an alloy of copper with eight or ten per cent of tin. Cannons are cast from a similar alloy. Bell-metal is composed of eighty parts copper and twenty tin. Speculum-metal, used for the mirrors of reflecting telescopes, consists of two parts copper and one tin.

434. The best brass is made of four parts copper to one zinc. When the zinc is in greater proportion, an imitation-gold, called pinchbeck, is formed.

435. The art of tinning copper consists in first polishing the copper, placing small pieces of tin on its surface, and raising the heat so as to fuse them; as soon as this takes place, the copper is rubbed over with a piece of tow. Iron is tinned with greater difficulty than copper.

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436. Tinsmiths' solder is an alloy of lead and tin in variable proportions.

437. Equal parts of tin and zinc fused, and then agitated in a box with two parts of hot mercury, form the coating usually employed in electrical machines. An amalgam of tin is used to coat the backs of looking-glasses.

438. "German silver" is an alloy of copper, zinc, and nickel in variable proportions according to the quality, and mainly depending for its whiteness on the amount of nickel present.

439. When steel is alloyed with one hundredth part of platinum, the alloy possesses great toughness and tenacity. The best razor-steel is alloyed with a minute portion of silver. Mr. Morries Stirling has taken out a patent in England for several alloys of iron, remarkable for their hardness, toughness, sonorousness, and low point of fusibility.

440. Silver coin should contain about a thirteenth part of its weight of copper. The postage three-cent pieces, however, contain a much larger proportion.

441. A large portion of native gold is found alloyed with silver. Gold coins generally contain about one-twelfth of their weight of copper, added to make them harder and more durable. For the same reason, gold used in the arts is alloyed with an alloy of copper and silver. An amalgam, composed of one part gold and eight parts mercury, was at one time used in gilding brass buttons.

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PART SECOND.

CHAP. I.—CHEMISTRY OF PLANTS AND ANIMALS.

442. Organic Chemistry is a complicated and difficult branch of the science, but not on account of the number of elementary bodies concerned. Six elements constitute nearly the whole substance of plants and animals; viz., Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus, and Sulphur: indeed, the two last form but a very small part of either, so that only four elements enter largely into their composition. This department of the subject is rendered difficult by the great number of equivalents which generally go to make up a single substance, and by the proneness of all organic bodies to undergo decomposition.

443. Most organic compounds burn readily in the air, and leave but a small residue; whereas inorganic matter is more capable of withstanding the fire, and remaining fixed or permanent.

444. All organized bodies contain water as an essential part of their structure, and some consist of water in very large proportion. (See par. 73.)

445. An *organized* body is one which possesses or has possessed life. An *organic* substance is that which has at some period formed a part of a plant or animal.

446. In treating of organic substances, chemists recognize two classes; namely, proximate principles, and ultimate elements.

447. Proximate Principles are those substances which may be easily separated, and which have previously existed in that form before separation. For instance,

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milk spontaneously separates into two parts, — cream and skim-milk. From cream we readily separate BUTTER, which is therefore reckoned one of the proximate principles contained in milk. If we now add a weak acid to the remaining skim-milk, the latter is separated into curd and whey; so CURD is another proximate principle. By evaporating the whey, we get a kind of SUGAR, and also inorganic salts. All these — butter, curd, sugar — were originally present in the milk; they were not formed or produced during the processes employed to separate them; and, to convey this idea, they are also called *educts*.

448. With the help of strong chemical agencies, we may produce new compounds from organic matter. By boiling sugar in aquafortis, we produce Oxalic Acid, — a poison; by fermenting corn, we produce alcohol, — another poison: but sugar contains no Oxalic Acid, and corn contains no alcohol. Such substances are therefore distinguished by the name of *products*.

449. ULTIMATE ELEMENTS are those simple bodies (already examined in Part First) into which all organic matter can be finally resolved. Thus, on taking sugar to pieces, we find that it consists of Carbon, Oxygen, and Hydrogen; and these are *its* ultimate elements. If we analyze corn, besides the three elements just mentioned, we find Nitrogen, Phosphorus, and Sulphur; and these six are *its* ultimate elements.

450. Organized bodies, in their ordinary state, have a strong tendency to decomposition. This tendency, during life, is counterbalanced by reparative provisions; but, after death, decomposition goes on unchecked.

451. DECAY, or *eremacausis*, as explained by Liebig, is a process of slow combustion requiring free access of air and the presence of moisture, in which Oxygen unites with the Carbon and Hydrogen of the plant, forming Carbonic Acid and Water. Decay is arrested in an organized structure by cutting off the supply of air, by thorough drying, by lowering the temperature to 32°, and by the addition of common salt, sugar, mineral acids, alcohol, oil of turpentine, or corrosive sublimate. Familiar examples of all these methods will occur to the student, as the preserving of cooked food in air-tight canisters, or fresh meat in ice-rooms on board ocean

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steamers, dried fruits, jerked flesh, sugar or salt-cured hams, and the preservation of anatomical preparations in alcohol or with corrosive sublimate. On the other hand, Decay is hastened by the addition of alkalies, and also by a moderately warm temperature.

452. FERMENTATION and PUTREFACTION are secondary processes, preceded by Decay, in which the elements of a body form new compounds by intestinal changes, but no single element is set at liberty. These transformations generally occur under water, or in similar situations where air is excluded. Minute particles of either fermenting or putrefying bodies possess the property of setting the process agoing in almost unlimited quantities of fresh organic matter.

453. Fermentation is the metamorphosis of substances which do not contain nitrogen; and its gaseous products have no marked odor. Any substance capable of converting sugar into Alcohol and Carbonic Acid is called a ferment. Nearly all azotized organic bodies possess this property, and yeast in a pre-eminent degree. The conversion of starch into sugar is called the *saccharine* fermentation; that of sugar into alcohol, the *vinous* fermentation; and that of alcohol into vinegar, the *acetous* fermentation.

454. Putrefaction takes place in tissues containing Nitrogen, and is attended with a disagreeable odor.

PROXIMATE PRINCIPLES, OR EDUCTS,

COMPOSED OF C, O, AND H.

455. The following neutral proximate principles — Lignine, Gum, Sugar, Fat — do not contain Nitrogen, and so are commonly styled "non-azotized" compounds. All of them are found in plants, and some in animals. It will be observed, that there is a striking similarity in their composition, and that in each the Hydrogen and Oxygen exist in the exact proportions to form water.

456. LIGNINE is the woody part of plants, freed from gum, starch, and juice. Fine linen and cotton are nearly pure specimens of lignine, and baked wood contains about ninety-five per cent. Lignine is distinguished for its

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insolubility, being unacted upon by water, alcohol, ether, weak acids or alkalies. But by steeping linen rags in strong oil of vitriol, and afterwards triturating the mass until it becomes a homogeneous pulp, they are finally dissolved; and if we boil this adhesive solution along with water for several hours, adding more water from time to time, they may be changed into grape-sugar. Symbol, $C_{12}H_8O_8$.

457. STARCH forms the largest part of dried esculent vegetables, as potatoes, corn, rice, wheat, &c. Starch is insoluble in cold water, but forms a gelatinous, cloudy solution with boiling water. Tincture of iodine strikes a blue color with a cold solution of starch. After long boiling in weak acid, starch is converted into a kind of gum called Dextrine; and, if the boiling be continued still longer, the dextrine is finally converted into grape-sugar. Similar changes occur in the starch of fruits, as apples, peaches, &c., during ripening. Symbol, $C_{12}H_9O_9$.

458. GUM forms a part of most vegetable juices, and in some plants a large part at certain stages of growth. Gum Arabic is soluble in cold water. It is employed as a menstruum and demulcent in medicine; also in making water colors. An artificial or starch-gum is now substituted for gum Arabic by calico-printers and others. Symbol, $C_{12}H_{11}O_{11}$. "Gum Tragacanth" requires boiling water for solution. Many resins are popularly, though erroneously, called gums, as "gum benzoin."

459. SUGAR. — There are three well-marked varieties; namely, cane-sugar, grape-sugar, and lactine or sugar of milk, all of which are capable of undergoing the vinous fermentation. The first is commonly procured from the sugar-cane, maple-tree, and beet-root. It is soluble in one-third of its weight of cold water; and, when crystallized slowly from a large quantity, forms beautiful four-sided crystals of specific gravity 1.60. Four parts of sixty-six per cent alcohol dissolve one of sugar. It melts at 365°. Sugar is an excellent antiseptic. At first, sugar was only employed in medicine, and its domestic use seems to have commenced in Europe about the time of the Crusades. The cultivation of sugar-cane was carried on in Cyprus and Madeira during the twelfth century; and, in 1506, it was transplanted to the West

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India islands. In 1747, Marggraf, a German chemist, discovered that cane-sugar might be economically extracted from beets; and, fifty years later, manufactories were established for that purpose, and are still carried on in France and Germany. From eight to twelve million pounds of cane-sugar are procured annually from the spring sap of the maple-tree. Indian-corn stems contain a large amount of cane-sugar, more especially before the formation of the ear.

460. GRAPE-SUGAR is the variety found in honey, grapes, and indeed most of the sub-acid fruits. Grape-sugar is artificially produced when lignine or starch is boiled in weak Sulphuric Acid. It melts at 212°, is much less soluble in water than cane-sugar, and not half as sweet. Large quantities of this sugar are manufactured from starch, and employed to adulterate cane-sugar. The crystals are cubical, and have a specific gravity of 1.38. Symbol, $C_{12}H_{14}O_{14}$.

461. LACTINE, or Sugar of Milk, is obtained from whey by evaporation and crystallization. When purified with animal charcoal, it appears white and translucent, forming four-sided crystals, hard, gritty, and but slightly sweetish. Symbol, $C_{24}H_{24}O_{24}$.

462. OILS and FATS. — The word *oil*, strictly speaking, includes all fatty bodies, vegetable butters and essences. These may be divided into *fixed* or fatty, and *volatile* or essential oils. They are all soluble in ether. Castor-oil is the only one completely soluble in alcohol.

463. FIXED OILS are those which cannot be separated by distillation, and are generally obtained by pressure. They produce a greasy stain upon paper, not removable by heat, and are further subdivided into *solid fats* and *liquid oils*. These are found both in plants and animals. In plants, they occur chiefly in the seeds and fruit; in animals, diffused through the cellular tissue, cavities of bones, &c., and, being bad conductors of heat, they help to protect the internal parts from sudden changes of temperature. During hybernation and disease, fat is absorbed, and made use of to keep up the animal heat.

464. VOLATILE OILS are prepared from certain plants by distillation with water. They have very high boiling points; but, when distilled along with water, they rise

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in vapor at a much lower temperature. This explains why the odors of plants (which depend upon volatile oils) are so much more perceptible after rain. The stain left by a volatile oil upon paper disappears when heated.

465. Chevreul first established the fact that organized bodies contain proximate principles, and, consequently, that their constitution cannot be determined by ultimate analyses; for such analyses tell us only their *composition*, not the arrangement of these elements into groups, or, in other words, their *constitution*. Chevreul ascertained, that fatty substances contain three proximate principles, — Stearine, Margarine, Oleine, — the two former solid, the latter a liquid, at ordinary temperatures.

466. STEARINE is best prepared from mutton-suet. The suet is firmly pressed in calico cloths; an oil exudes, and solid stearine is left, which may be dissolved in warm ether and crystallized. MARGARINE may be prepared in the same way from goose fat. The solid portion of human fat also consists of margarine.

467. OLEINE — the fluid proximate principle — is more abundant in some fats than others. In almond and olive oils, it forms the chief part, and it may be procured by pressing lard between folds of white blotting-paper, and repeatedly exposing the fluid portion to cold, which precipitates the remaining stearine. Pure oleine is used sparingly to lubricate delicate machinery, as clocks and watches.

468. The three proximate principles of fat already examined, themselves consist of three corresponding acids, — Stearic, Margaric, and Oleic Acids, — each in combination with a sweet-tasted, uncrystallizable base called Glycerine. In the formation of soap from fat and alkali, these acids leave their base, and unite with the potassa or soda.

VEGETABLE ACIDS.

ACETIC, TARTARIC, OXALIC, CITRIC, MALIC, TANNIC.

469. ACETIC ACID, or Vinegar, is found in the juice of certain plants, combined with potassa. There are two distinct processes by which it is prepared on the large scale. First, from alcoholic liquors by means of acetous

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fermentation, which essentially consists in alcohol combining with Oxygen. Wine and beer vinegars are manufactured by exposing these liquors to the oxidizing action of air, aided by a little ferment; and their peculiar odor is due to acetic ether. Second, by distilling hard wood in large iron retorts we get wood-vinegar, or pyroligneous acid, which, after rectification, yields strong Acetic Acid. This is extensively used in curing flesh-meat, and contains a little kreosote. Symbol, $\overline{A}$, or $C_4 H_3 O_3 + HO$.

470. TARTARIC ACID — discovered by Scheele in 1770 — is procured from the crude tartar deposited in wine casks by converting it into Tartrate of Lime with powdered chalk, and then separating the lime with dilute oil of vitriol. This is the acid contained in grapes, pine-apples, &c., generally combined with potassa. Tartaric Acid is used in medicine, and also by calico-printers to evolve Chlorine from bleaching liquor. It crystallizes readily, and is soluble both in water and alcohol; but the aqueous solution grows mouldy if long kept. Symbol, $\overline{T}$, or $C_8 H_4 O_{10} + 2\,HO$.

471. OXALIC ACID — discovered by Scheele in 1776 — occurs in common rhubarb, sorrel, and several other plants, and is also found as a mineral, combined with iron oxide. It is prepared on the large scale by digesting potato-starch in eight times its weight of weak Nitric Acid, with moderate heat, so long as red fumes are disengaged. The crystals are soluble in their own weight of boiling water, also in four parts of cold alcohol, and are very poisonous. They have often been administered in mistake for Epsom salts. Oxalic Acid may be easily distinguished from the latter by its reddening effect on a drop of black ink, whereas Epsom salts do not affect ink. The antidotes are chalk or magnesia. Symbol, $\overline{Ox}$, or $C_2 O_3 + 3\,HO$.

472. OXALATE OF AMMONIA, prepared by saturating a solution of the carbonate with Oxalic Acid, is the most most delicate test we have for lime. (See par. 263.)

473. CITRIC ACID — discovered by Scheele in 1784 — is obtained from lemon-juice by the same process as that for Tartaric Acid. It forms beautiful transparent crystals, which have a mild acid taste, and are very soluble in water. Gooseberries and currants also contain this

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acid. If adulterated with Tartaric Acid, a solution of caustic potassa will throw down a precipitate of cream-of-tartar. Symbol, $\overline{Ci}$, or $C_{12}H_5O_{11}+3HO$.

474. Malic Acid is found in rowan-tree berries, pears, apples, rhubarb, &c. It has an agreeable acid taste, is soluble both in water and alcohol, but cannot be easily crystallized. The aqueous solution becomes mouldy by keeping. Symbol, $\overline{M}$, or $C_8H_4O_8+2HO$.

475. Tannic Acid, or Tannin, is the astringent principle in plants. It may be procured from gall-nuts, which are excrescences produced on oak leaves by the puncture of a fly and the deposit of its egg. Take powdered gall-nuts in a glass tunnel loosely stopped with tow, pour on sulphuric ether, and, placing a card-board over it, allow the solution to filter through into a bottle. Two liquids result; a heavy one, which is principally an aqueous solution of Tannic Acid, and a light one floating above, which is the ether and coloring matter. The same acid may be prepared from oak bark, and it is the active agent in tanning skins. Leather is a Tannate of Gelatine. Common black ink is a Tannate of Iron. Long exposure to the air converts Tannic into Gallic Acid. Symbol, $\overline{At}$, or $C_{18}H_5O_9+3HO$.

FAMILIAR PRODUCTS.

ALCOHOL, PYROLIGNEOUS SPIRIT, FUSEL OIL, ETHER, CHLOROFORM.

476. Absolute Alcohol is a clear, colorless liquid, inflammable, hygroscopic, and antiseptic, with a high refracting power, which boils at 177°, and has never been frozen. Specific gravity, 0.792. Alcohol is invariably a product of the fermentation of sugar. It is a powerful solvent of resins, essential oils, iodine, most of the deliquescent salts, &c. As ordinarily met with, it is diluted with more or less water. The strongest rectified spirit of wine contains about ninety per cent of absolute alcohol; brandy and similar spirits, fifty per cent; port and sherry wines, twenty per cent; champagne wine, twelve per cent; strong ale, from six to ten per cent; strong cider, nine per cent; small beer, one per cent.

477. In the process of baking bread, the alcohol generated during fermentation is dissipated. It has been

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calculated that no less than 300,000 gallons of proof spirit are annually lost in London from the bread baked in that city. An attempt was once made to save the alcohol from bread, at Chelsea military bakehouse, and $100,000 spent upon apparatus, without success. It was found that, in order to get the alcohol, the bread required to be baked so hard that it was uneatable. In Tartary, an ardent spirit called *arraca* is distilled from fermented mares' milk. Symbol, $C_4H_6O_2$.

478. Pyroligneous Spirit. — During the dry distillation of hard wood, an inflammable liquid comes over, resembling alcohol in its composition and properties, commonly called "wood spirit." It forms about one-hundredth part of crude wood vinegar, from which it is separated by a second distillation. Wood spirit has a peculiar fiery odor and taste, and is a good solvent, like alcohol. Large quantities of it are used in the arts as a substitute for alcohol. Symbol, C_2H_3O+HO.

479. Fusel Oil. — When brandy is distilled from mashed potatoes, or whisky from a mixture of malt and raw grain, large quantities of an acrid oil come over towards the close of the process. It is inflammable, irritating, and highly poisonous. Cheap spirits are often contaminated with it; and fatal accidents from inhaling chloroform have been ascribed by some to the presence of fusel oil in the alcohol from which it was manufactured. Symbol, $C_{10}H_{11}O+HO$.

480. Ether, from alcohol, seems to have been known as early as the thirteenth century. There are three kinds, according to the acid employed; namely, sulphuric, nitrous, and hydrochloric ethers. Sulphuric ether is the most common, and is prepared by mixing nine parts of strong Sulphuric Acid with five parts of ninety per cent alcohol, and, after remaining twenty-four hours in a cool place, distilling the mixture. Ether passes over, and may be rectified by a second distillation along with an alcoholic solution of potassa. It is a colorless, limpid fluid, with a penetrating odor, which boils at 98°, and has a specific gravity of 0.72. Of late years, ether has been extensively used to produce insensibility to pain during surgical operations. It is inhaled in vapor, diluted with atmospheric air; and it should be borne in

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mind that this mixture is explosive. In many persons, even the diluted vapor excites severe spasm of the glottis. Ether also serves as a good solvent for fixed oils, phosphorus, salts of gold, &c. Symbol, C_4H_5O.

481. NITROUS and HYDROCHLORIC ETHERS are produced in a similar way by the action of the respective acids on alcohol. Nitrous ether is a pale-yellow fluid, with an odor resembling that of apples. An impure article is sold by druggists under the name of "sweet spirits of nitre." Symbol, C_4H_5,NO_4. — Hydrochloric ether is extensively used as an anæsthetic agent. Symbol, C_4H_5Cl.

482. Analogous ether compounds, possessing marked aromatic odors, may be prepared from wood spirit, and also from fusel oil, by corresponding processes.

483. CHLOROFORM was discovered by Dumas, and is best prepared from pure alcohol, although wood spirit is often employed for that purpose. One part of recently-slaked lime is stirred into twenty-four parts of cold water, and Chlorine gas passed through it till the lime is nearly all dissolved. This is mixed with one part of alcohol, and, after standing in a cool place overnight, may be put into a large retort, and slowly distilled. Chloroform is a heavy, colorless liquid, with an enduring sweet taste; and the stupefying, narcotic effects produced by inhaling its vapor are well known. Specific gravity, 1.48. Symbol, C_2HCl_3.

PROXIMATE PRINCIPLES CONTAINING NITROGEN.

FIBRINE, ALBUMEN, CASEINE.

484. According to Liebig's theory, starch, sugar, and other non-azotized principles present in our food, serve mainly as fuel to keep up the animal heat; but those portions of food capable of forming blood always contain Nitrogen as one of their ultimate elements. In both vegetable and animal tissues we find three azotized proximate principles destined to form blood, and so build up the animal body; namely, Fibrine (lean flesh), Albumen (white of egg), and Caseine (cheese).

485. FIBRINE is readily procured by stirring recently-drawn blood with a stick, when it adheres in stringy

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masses of a greyish color. Fibrine may also be obtained from certain vegetable juices, such as those of carrots and turnips; and its chemical composition is identical with that of fibrine from blood. The property which distinguishes fibrine from the other two is, that it spontaneously coagulates at ordinary temperatures, forming a clot, which floats on the top.

486. ALBUMEN may be recognized by this property; it coagulates or solidifies at 212°, and then becomes insoluble in water. In this way, albumen may be readily detected in blood-serum, of which it forms a large part, in the juice of flesh and culinary vegetables, in flour, nuts, almonds, &c. It is the albumen contained in blood which enables that fluid to retain Phosphate of Lime in solution, which is needed for the growth and repair of bone. Albumen in solution is also coagulated by nut-galls, sugar of lead, or corrosive sublimate; hence its use as an antidote for the two latter poisons. It is owing to the presence of sulphur in albumen that a silver spoon becomes blackened when used to eat a boiled egg.

487. CASEINE is that part of milk which curdles or solidifies on adding an acid. Skim milk cheese is nearly pure caseine. It may also be procured from peas and beans. Caseine is distinguishable by the circumstance of requiring an acid to coagulate it. When milk curdles after long standing, it is due to the formation of Lactic Acid from the milk-sugar. Caseine remains dissolved in fresh milk because it is combined with certain alkaline salts; but when an acid is formed, or added, it combines with these salts, and so the caseine is precipitated.

488. The exact composition of fibrine, albumen, and caseine has not yet been satisfactorily ascertained; but they are very nearly alike. Each consists of about fifty-five per cent of Carbon, seven of Hydrogen, twenty-two of Oxygen, fifteen of Nitrogen, and fractional parts of Sulphur and Phosphorus.

489. It is highly probable that the animal organism possesses power to transform albumen into fibrine or caseine, or *vice versa;* albumen, however, seems to be the starting-point of all the tissues. Thus, the principal bulk of an egg is albumen, with a minute portion of oil and iron; yet from these are produced the fibrine in the

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chick's muscles, also the horny tissue and feathers. In suckling a young animal, it is evident that caseine must be similarly transformed; or, if we reverse the examination, the parent gets her milk (so rich in caseine) from blood, which contains none.

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490. GLUTEN is an adhesive substance, most readily procured from wheaten flour by carefully washing away the starch through coarse muslin or a fine wire sieve. It consists principally of vegetable fibrine combined with a very sticky compound like birdlime, and a little oil. Wheaten flour contains ten per cent of gluten; bran, eighteen; oatmeal, eighteen; Indian corn meal, twelve; dry potatoes, eight; rice, seven. The nutritive value of vegetable food depends upon the proportion of gluten it contains.

491. GELATINE — the tremulous, semi-solid substance got by boiling calfs' feet — does not exist as such in the animal tissues, but is formed during the boiling to which they are subjected. "Size" is a coarse sort of gelatine, prepared from scraps of hides, hoofs, &c.; and "glue" is the same substance dried in thin pieces. "Isinglass" is a pure variety, made from fishes' air-bladders and other membranes, and is used to clarify wine and coffee. Gelatine may also be procured from ground bones by long boiling under extra pressure. It appears that gelatine, although rich in Nitrogen, cannot form blood; an animal fed on it exclusively, dies with all the symptoms of starvation; but it probably serves to nourish the gelatinous tissues, as it it proves eminently useful, along with other diet, in convalescence.

VEGETABLE ALKALOIDS.

MORPHIA, QUINIA, STRYCHNIA.

492. Vegetable alkaloids are all capable of neutralizing acids, inorganic as well as organic; indeed, they seem to have a sort of preference for the inorganic, for when a plant finds a sufficient quantity of an inorganic acid in the soil, its alkaloid combines with it. They are found

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in all parts of the plant, though principally in the leaves. They are all decomposed by heat, and, on burning, should leave no residue.

493. MORPHIA, or Morphine — the active principle of opium — was discovered by Sertuerner, in 1804. To prepare it, first make an infusion of opium in cold water; after concentration, precipitate it with Carbonate of Soda, and dissolve the washed precipitate in weak Acetic Acid. This gives Acetate of Morphia, and the alkaloid itself may then be thrown down as a white powder by adding ammonia. To procure it quite colorless, the solution should be filtered through animal charcoal, and crystallized from hot alcohol. Morphia has an intensely bitter taste, and is remarkable for its powerfully narcotic effects; five or six grains being sufficient to kill a man. It is not very soluble in water, insoluble in ether, but easily dissolved in warm alcohol. In medicine, the Hydrochlorate, Sulphate, and Acetate of Morphia are the salts employed. Deaths resulting from overdoses of this dangerous medicine are too common. Nitric Acid turns morphia or its salts of an orange-red color. Symbol, $C_{35} H_{20} O_6 N$.

494. QUINIA, or Quinine, — the active principle of Peruvian bark — was discovered by Pelletier and Caventou. It may be prepared by boiling a decoction of ground bark with slaked lime, and dissolving the washed precipitate in hot alcohol, from which, after filtration, quinine is deposited. Quinine tastes intensely bitter, is sparingly soluble in water, but dissolves freely in alcohol or ether. Sulphate of Quinia forms feathery, snow-white crystals, when pure. This is the salt generally used in medicine; but it is often adulterated with various substances, as gypsum, magnesia, sugar, starch, stearic acid. It is a specific remedy for fever and ague. Symbol, $C_{22} H_{12} O_2 N$.

495. STRYCHNIA, or Strychnine, is the poisonous alkaloid contained in nux vomica, and the process for its preparation is similar to those for the preceding two. Strychnia exercises an extraordinary influence over the nervous and muscular systems, often producing spasmodic contractions of the muscles even when administered in medicinal doses for paralysis. It is an energetic poison, and has of late become somewhat popular with suicides. Symbol, $C_{42} H_{23} O_4 N_2$.

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496. Besides those already described, chemists are acquainted with a great many more alkaloids of less practical importance. Such are NICOTINE, the active principle of tobacco, one drop of which is sufficient to kill a dog; CONICINE, the alkaloid in hemlock; SOLANINE, found in colorless potato-shoots which grow in dark cellars; and EMETINE, the active part of ipecacuan.

497. THEINE or CAFFEINE — the essential principle of both tea and coffee — is, in some respects, an analogous compound to the preceding bodies. In others, however, it materially differs from them. It has but a slightly bitter taste, and is not poisonous. Liebig thinks that it assists the formation of bile, and so, secondarily, serves to furnish matter for keeping up the animal heat. Symbol, $C_8 H_5 O_2 N_2$.

ORGANIC RADICALS.

498. An "organic radical" is a compound body which stands in the relation of an element to several other bodies; that is, it combines with them, and may be separated from them, without itself undergoing decomposition. Many of these bodies are as yet only hypothetical. For example, ETHYLE is reckoned the organic radical or *foundation* of alcohol and its derivatives; but ethyle has never been procured in a separate form. METHYLE, in like manner, is the organic radical of wood-spirit, and AMYLE of fusel oil. The following table will help the reader to understand this better: —

ETHYLE contains	$C_4 H_5$
Sulphuric ether contains .	$C_4 H_5 O$, called Oxide of Ethyle.
Alcohol contains	$C_4 H_5 O + HO$, = Hydrated do.
METHYLE contains	$C_2 H_3$
Wood-spirit ether contains	$C_2 H_3 O$, called Oxide of Methyle.
Wood-spirit contains . . .	$C_2 H_3 O + HO$, = Hydrated do.

And so on with many other compounds formed by the union of these radicals with other bodies. It is evident that this system very much simplifies the examination of organic substances, besides being a great aid to memory.

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CYANOGEN AND ITS COMPOUNDS.

499. CYANOGEN — the best marked and earliest noticed of the organic radicles — was discovered by Gay Lussac in 1815. It is a poisonous, colorless gas, with a pungent odor, resembling that of peach blossoms; it is not a supporter of combustion, but is itself inflammable, burning with a beautiful purple flame. Cyanogen is easily prepared from Bicyanide of Mercury by heating that salt in a small hard-glass retort, and collecting the gas over quicksilver. Water dissolves about four times, and alcohol twenty-three times its bulk of the gas. Gay Lussac called it cyanogen (from *κυανος, blue*, and *γενναειν, to generate*), because it is the fundamental ingredient in Prussian blue. Specific gravity, 1.80. Symbol Cy, or NC_2.

500. HYDROCYANIC or PRUSSIC ACID, in the concentrated state, is a deadly poison, of which a single drop is sufficient to kill a large dog. The utmost care should be taken to avoid breathing the vapor during its preparation. Prussic Acid exists in peach blossoms and bitter almonds. For medicinal use, it may be prepared by dissolving seventy-two grains of Tartaric Acid in one ounce of distilled water, in a small stoppered vial, adding thirty-two grains of Cyanide of Potassium. Immediately close the vial, and, keeping a finger on the stopper, shake it in a basin of cold water. After standing in a dark place for twelve hours, the clear liquid may be decanted off, and will contain thirteen grains (twenty-six full doses) of Hydrocyanic Acid. It has a penetrating odor, dangerous to inhale even when diluted. It is extremely liable to undergo decomposition, especially the strong acid. A drop of weak, pure Sulphuric Acid tends to preserve the medicinal preparation. The best remedy, in cases of poisoning with prussic acid, is cold affusion over the head and shoulders, and respiring diluted ammonia or chlorine. If swallowed, freshly precipitated black oxide of Iron is the best internal antidote. The latter may be got by precipitating a mixture of the Sulphate and Chloride of Iron with Carbonate of Potassa. Anhydrous prussic acid boils at 80°, and freezes at zero. Specific gravity, 0.75. Symbol, HCy, or HNC_2.

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501. CYANIDE OF POTASSIUM may be prepared by fusing eight parts of dried Ferrocyanide of Potassium and three of dried Carbonate of Potassa, in an iron crucible, until gas ceases to come off; the clear fused salt may then be poured out on an iron plate, and carefully bottled when cool. By long exposure to the air, it becomes entirely carbonated. Cyanide of Potassium is very deliquescent; it is soluble both in water and alcohol, and is very poisonous. It is much used by chemists as a reducing agent, and, in the arts, as a solvent for salts of silver. It removes the stains left on the skin by gold or silver solutions, but should be used with great caution, and the part well washed with water after its application. Symbol, K Cy.

502. SULPHOCYANIDE OF POTASSIUM may be prepared by heating two parts of dried ferrocyanide and one part of pure sulphur, in a covered crucible, until the gaseous bubbles take fire; set it aside to cool; afterwards dissolve the fused mass in boiling water, and add a solution of caustic potassa (which precipitates the iron), drop by drop, so long as the original solution turns red on mere exposure to the air. Sulphocyanide of Potassium is a colorless salt, remarkable for striking a deep blood-red color with solutions of the persalts of iron. Symbol, K Csy, or K S_2 Cy.

503. FERROCYANIDE OF POTASSIUM, or Yellow Prussiate of Potassa, is manufactured on a large scale for use in the arts. Crude potash is heated in a covered iron pot until it liquefies; dried blood, hoofs, and other refuse animal matter, along with iron filings, are then added, and the whole brought to a dull-red heat. After cooling, hot water is poured on, and the whole freely exposed to the air for several hours; on filtration, the ferrocyanide is deposited in flat crystals of a yellow color, which lose their crystallization-water at 212°, and become white. This salt has a sweetish-bitter, changing to a saline taste, and is not poisonous, but purgative. It is not soluble in alcohol. Symbol, K_2 Cfy, or 2 K Cy, Fe.

504. Common Prussian blue is a Ferrocyanide of Iron, and is produced in testing for iron. (See par. 307.) It is extensively used both as an oil and water color, but is by no means permanent. Cyanide of Silver is used in electroplating.

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CHAPTER II. — POISONS.

505. That department of chemistry which treats of poisons is called Toxicology, from τοξικον, *pertaining to bows and arrows*, and λογος, *a discourse*, and evidently refers to the ancient practice of using poisoned arrows.

506. A poison may be briefly defined as a substance which, when taken into the system, injures or destroys the functions of life.

507. It is not always necessary that a poison should be swallowed in order to produce its characteristic effects. Most poisons operate with frightful rapidity when injected into a vein; and some act energetically even when rubbed on abraded skin, or applied to a mucous surface, as the white of the eye.

508. Certain poisons, such as mercury and foxglove, when taken in daily small doses, have a tendency to accumulate in the system, and all at once manifest themselves by symptoms similar to what might have been looked for, had the whole quantity been taken in a single dose. These are called *cumulative* poisons.

509. As a general rule, poisons are dangerous in proportion to their easy solubility; and, as a natural sequence from this rule, an antidote is something which unites chemically with a particular poison, and so renders it insoluble, or, at all events, inert.

510. A large dose is generally more fatal than a small one; but sometimes an extra large dose saves the patient's life by inducing rapid nausea and vomiting. In most cases, too, the after-death appearances are materially modified, or even changed, by the quantity administered. For example, when death results from a very large dose of arsenic, we seldom or never find the stomach inflamed, which always occurs in ordinary cases.

511. Habit exercises considerable influence over the common effects of poisons; so that, by a gradual process, one may at length manage to *survive* doses which would certainly kill a person not in like manner habituated.

512. In testing for poisons after death, scrupulous care must be observed in the various processes regarding

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cleanliness, purity of materials, and honesty; and every test must produce a *decided* effect, otherwise it should be allowed to go for nothing.

513. Most of the common poisons have been already examined under their respective heads. The following gives a tabular view of their antidotes: —

NAME.	ANTIDOTE.
Arsenic	Hydrated Sesquioxide of Iron.
Carbonic Acid and other poisonous gases . .	Cold affusion, artificial respiration.
Corrosive sublimate .	White of egg, or milk.
Laudanum, morphia .	The stomach-pump, or an emetic.
Mineral acids . . .	Chalk, or magnesia.
Oxalic Acid	Chalk, or lime-water.
Prussic Acid	Cold affusion, ammonia or chlorine.
Strychnia	Dilute tincture of iodine.
Sugar of lead, &c. . .	Epsom salts, or Tasteless salts.
Tartar emetic . . .	Tincture of Peruvian bark.
Verdigris, copper-salts	White of egg, or iron filings.

In all cases it is well to induce vomiting immediately, by tickling the patient's throat with a feather, administering lukewarm water, or a teaspoonful of mustard diffused through a glass of tepid water.

514. The frequency with which poison is administered with intent to murder, renders it highly necessary that measures of a precautionary nature should be taken by those who retail it. Prevention, in such cases, has not received the attention it merits. We may be very expert analysts; but this ability of after-detection does not much lessen the evil; whereas, by enabling the intended victim to suspect the presence of poison beforehand, many lives might be saved. It has been proposed to add a few grains Sulphate of Iron and Ferrocyanide of Potassium to every dram of arsenic retailed by the druggist, so that, when put into any liquid, the deep blue produced would excite suspicion.

515. Much injury to health results from the universal use of LEAD in the form of pigments, glazing to earthenware, water-pipes, &c. Zinc paint, in a health point of view, is unobjectionable; and block-tin or gutta percha pipes to convey water should be employed by all who wish to avoid lead colic and palsy.

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CHAPTER III. — MISCELLANEOUS.

FRIGORIFIC MIXTURES.

516. The following groups are given in the order of their cooling power, beginning at the least. Particular attention should be paid to surrounding influences. The vessels used should be thin, and good conductors of heat. Metallic ones are preferable when acids form no part of the mixture, or they may be used even then if previously coated with wax. The vessel itself should be placed in cold water: —

Cold spring water	16	parts by	weight.
Hydrochlorate of Ammonia .	5	„	„
Nitrate of Potassa	5	„	„
Dilute Sulphuric Acid . . .	4	„	„
Sulphate of Soda	5	„	„
Dilute Nitric Acid	5	„	„
Sulphate of Soda	6	„	„
Hydrochlorate of Ammonia .	4	„	„
Nitrate of Potassa	2	„	„
Snow	2	„	„
Common salt	1	„	„
Hydrochlorate of Ammonia .	1	„	„
Common salt	2	„	„
Snow	5	„	„
Hydrochloric Acid	5	„	„
Snow	8	„	„
Snow	8	„	„
Dilute Sulphuric Acid . . .	10	„	„

The salts should be fresh crystallized, dry, and finely powdered; the snow should not be pressed; and, if experimenters recollect that it is *during solution* the cold is manifested, they will see the propriety of mixing the ingredients quickly, and at the exact time wanted. Dilute Sulphuric Acid means equal weights of the acid and water; dilute Nitric Acid consists of two parts acid to one of water: and both must be allowed to cool before use.

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GUN COTTON.

517. Mix equal parts, by measure, of strong Nitric and Sulphuric Acids. The Nitric Acid should have a specific gravity of at least 1.48; and the Sulphuric Acid, 1.84. For the latter, Nordhausen oil of vitriol answers very well. The mixed acids are covered, and set aside to cool. Then take the finest cotton wool that can be got, and, having spread it out, immerse it in the mixed acids for two minutes; gently press out the superfluous acid, and wash the cotton thoroughly in a stream of clear water, continuing this process till the washings cease to redden litmus paper. Press the cotton as dry as possible with the hand, and dip it into a weak solution of nitre; again press firmly, and dry it at a temperature not exceeding 150°. In Schonbein's patent, it is specified that the cotton should lie in a covered vessel for an hour after the acid has been pressed out, before the washing. The "superfluous acid" may be used a second, and even a third time; but the quality of the article produced is inferior.

518. After complete drying, we find that the original cotton has gained about seventy per cent in weight, and has become highly explosive. Gun-cotton explodes at a much lower temperature than gunpowder. This may be illustrated by firing a piece of well-dried gun-cotton over and in contact with gunpowder, when the latter does not catch fire; or, by the experiment of firing gun-cotton on the bare palm, without scorching the hand. Good gun-cotton leaves no residue, and little or no smoke, after explosion; and it has been calculated to possess about four times the force of gunpowder. Gun-cotton attracts moisture from the atmosphere, but is not permanently injured thereby, as it may be dried again.

RAPID CRYSTALLIZATION.

519. Add as much Glauber's salt to a pint of water at blood-heat as it will dissolve, and immediately transfer the solution to a warm bottle, corking it tightly. When cold, it still remains liquid; but, on taking out the cork and stirring, it rapidly crystallizes into a nearly solid mass, and heat is evolved at the same time.

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SOAP.

520. In chemical language, any substance is a soap which forms a definite compound with Stearic, Margaric, or Oleic Acid. Thus, common "sticking plaster" is a soap of lead; and, in preparing stearine candles, one of the first steps in the process is to form a lime-soap. But the word *soap*, in ordinary language, is restricted to the compounds formed by boiling caustic soda or potassa with fat, oil, or resin; and these are distinguished for their cleansing power.

521. Tallow, cocoa-nut and palm butter are the principal fats used. Olive, hemp-seed, rape-seed, and fish oils, and common resin, are also used.

522. In making soap, it is necessary to use a *caustic* alkali, prepared in the way already mentioned (see par. 362). The ingredients must be boiled together a long time, and afterwards common salt added for the purpose of separating the soap completely from the fluid portions in which it is at first dissolved, soap being insoluble in salt-water. Carbonated alkalies may be employed when resin is substituted for tallow; but the compound formed is not a true soap.

523. The theory of saponification is now well understood. The stearine (or margarine or oleine) of the fat is decomposed into Stearic Acid and Glycerine, of which the former unites with caustic potassa (or caustic soda), and the latter is set free. Soap made with tallow and potassa is, therefore, Stearate of Potassa; with goose-fat and soda, Margarate of Soda; with olive oil and soda, Oleate of Soda. (See par. 468.)

524. Hard soaps are made from fats and non-drying vegetable oils in combination with soda; soft soaps, from fish oils and vegetable drying oils in combination with potassa. Resin soap is never very hard. A kind made from cocoa-nut butter is sold as "marine soap."

525. Even the hardest soaps retain a large quantity of water, amounting from twenty to seventy per cent. This may be easily verified by weighing a sample, cutting it into thin slices, and drying them at a moderate heat; after which, a second weighing, and comparison, will give the amount of water.

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BLACK WRITING INK.

526. Boil four ounces of ground nut-galls and two ounces of logwood chips in six pints of water until the decoction is evaporated down to half its bulk. Then strain it through coarse flannel; add two ounces of calcined green vitriol, one and a half ounce gum-arabic, and one ounce white sugar. The gum should be previously dissolved, and passed through a sieve; after adding the green vitriol, &c., the whole should be frequently stirred for a few days. The ink may finally be decanted off, a drop or two of kreosote added, and preserved in bottles.

527. Gall-nuts and logwood contain Tannic Acid, which forms a black precipitate with the persalts of iron. Gum serves to keep this precipitate suspended, and sugar imparts a glossy appearance to the ink when dry. Some manufacturers use Sulphate of Copper in addition to the ingredients specified; but, when steel pens are employed, its presence in the ink is objectionable, as metallic copper is precipitated on the pen.

MINIATURE VOLCANO.

528. Put twenty grains powdered Chlorate of Potassa into a tall conical glass, nearly fill it with warm water, and add a few small chips of phosphorus. Then, through a tube reaching to the bottom of the glass, pour on a dram of Sulphuric Acid, when a rumbling sound and flashes of light are produced, which continue for some time.

A MAGIC BLUE.

529. Put a few copper turnings into a vial, and fill it up with ammonia. After standing overnight, the solution has a blue color. Cork it well, and, by shaking it occasionally, after a time it becomes colorless. Take out the cork, and the solution soon turns blue again. These alternate changes may be repeated a great many times, and depend upon the absorption of oxygen from the air, oxidation of the copper, and the solution in ammonia of the oxide thus formed.

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LITMUS AND TURMERIC PAPERS.

530. Litmus Paper has a lavender-blue color, and is reddened by free acids. On this account, it is used as a preliminary test to ascertain the character of a doubtful fluid as to acidity. Litmus paper is prepared by boiling one part of powdered litmus in twelve parts of distilled water, using a glass flask. Filter, and divide the solution into equal parts; to the one add dilute Sulphuric Acid, drop by drop, till it assumes a slightly reddish tint; then mix the two, and in this liquid immerse narrow slips of unsized white paper, which, when dry, will be ready for use.

531. Turmeric Paper has a yellow color, which turns brown on being brought into contact with an alkali. It may be prepared by boiling one part of turmeric with six parts of dilute alcohol (made with equal parts of sixty per cent alcohol and water). The solution is then filtered, unsized paper dipped in the solution, and hung up to dry.

532. A convenient test-paper for ascertaining the presence of Hydrosulphuric Acid gas may be made by coating slips of cardboard with pure Carbonate of Lead in gum-water. This, and all other test-papers, should be kept in air-tight cases or bottles.

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DICTIONARY.

Alluvial strata, soil deposited by water, occurring most frequently at sides and mouths of rivers.
Anhydrous, entirely free from water.
Antiseptic, capable of resisting or retarding putrefaction.
Black flux, a reducing agent, prepared by heating cream of tartar to redness in a crucible.
Blowpipe, an instrument for raising the temperature of a flame by means of a stream of air. The apex or outer part of the flame is the hottest, and is called the "oxidizing flame;" while the inner or luminous part is called the "reducing flame."
Cautery, a corrosive or decomposing agent. The "actual cautery," as it is styled by surgeons, is a red-hot iron.
Cochineal, an insect employed as a red dye.
Escharotic, something which sears animal tissues; a cautery.
Felspathic rocks contain much felspar, and, after crumbling down, form beds of clay.
Flux, any thing added to an ore which renders it more fusible.
Frigorific, cooling or freezing.
Hydrate, a body chemically united with water.
Kelp, the fused ashes of certain kinds of sea-weed.
Ley, an alkaline solution.
Lixiviation, a process whereby soluble salts are separated from insoluble matter by adding water and filtering the mass.
Lute, a plastic substance applied at joinings to make them air-tight.
Miscible, a term applied to the intimate mixture of two fluids.
Narcotic, a benumbing, sleep-producing poison.
Nascent state, a gas in the act of being given off, not *after* its preparation and collection.
Neutral, neither acid nor alkaline; producing no change on litmus or turmeric papers.
Ore, a compound consisting of a metal chemically united with gaseous or earthy matter.
Pellicle, a thin skin which forms on the surface of solutions during evaporation.
Pigment, a dry color, which, when mixed with oil or water, forms paint.
Prism, a body with three sides.

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Reflectors of light, polished bodies which throw off light from their surfaces; which do not absorb or transmit it.

Sand-bath, a shallow iron vessel holding sand, placed over a fire, and used in heating or evaporating liquids.

Slag, the earthy refuse contained in ores, which combines with the flux, and floats above the melted metal.

Smalt, a blue powder used by potters, glass-workers, and painters. It is prepared by fusing sand and potash along with roasted ore of cobalt, and reducing the glass thus formed to powder.

Tabular crystals, having flat surfaces like a table.

Test, any thing which enables us to detect the presence of a particular substance.

Thermometer, an instrument for ascertaining the comparative temperature of different bodies.

Tincture, a solution of a substance in alcohol or strong spirit.

Vacuum, a space entirely empty.

Vitreous, glassy.

Zero, at one time, the lowest temperature indicated on Fahrenheit's thermometer, marked thus, 0°.

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